V. V. Golusina
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# ENGLISH

## for Radio Engineering Students

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## Modern Electronics and Electronic Devices

V. V. GOLUZINA,
Y. S. PETROV

# ENGLISH
## FOR RADIO ENGINEERING STUDENTS

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## MODERN ELECTRONICS AND ELECTRONIC DEVICES

Допущено Министерством высшего и среднего специального образования СССР в качестве учебного пособия для студентов электротехнических и радиотехнических специальностей вузов

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Данное пособие состоит из 10 разделов. В разделах 1-7 содержится 20 основных текстов с комментариями и упражнениями к ним. В разделы 8-10 включены тексты для дополнительного чтения.

Цель пособия—научить студентов читать оригинальную литературу на английском языке по специальности без словаря.

Тексты пособия взяты из оригинальной американской технической литературы. Вся система упражнений направлена на усвоение общетехнической и терминологической лексики, отличается обилием разнообразных по типам упражнений и включает элементы программирования. К упражнениям дан ключ.

В пособии имеется приложение и словарь.

Предназначается для студентов II и III курсов.

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Вера Васильевна Голузина, Юрий Сергеевич Петров

ПОСОБИЕ ПО АНГЛИЙСКОМУ ЯЗЫКУ
ДЛЯ РАДИОТЕХНИЧЕСКИХ И ЭЛЕКТРОТЕХНИЧЕСКИХ ВУЗОВ

Современная электроника и электронные приборы

*(на английском языке)*

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# ПРЕДИСЛОВИЕ

Учебное пособие «Современная электроника и электронные приборы» предназначено для студентов второго и третьего этапов обучения английскому языку электротехнических и радиотехнических вузов и факультетов и может быть использовано аспирантами, научными и инженерно-техническими работниками, изучающими английский язык.

Пособие соответствует вузовским программам по английскому языку и курсу электроники. В нем рассмотрены принципы работы электронно-вакуумных ламп, полупроводниковых диодов и триодов, усилителей, генераторов, выпрямителей и методы построения интегральных схем.

Тексты пособия взяты из оригинальных источников, некоторые из них частично адаптированы авторами.

Основной целью пособия является интенсификация обучения студентов чтению оригинальной литературы по специальности и освоение общетехнической и терминологической лексики.

Этим задачам подчинена его структура, отбор лексики, методика ее подачи, а также система упражнений.

В пособии нашли широкое применение различные типы лексических тестов с использованием программированных элементов.

Пособие рассчитано на 60—70 учебных часов аудиторной и 30—40 часов самостоятельной работы.

## Структура пособия

В пособие включено двадцать основных текстов, объединенных в первых семи разделах. В каждом разделе перед текстом имеются упражнения на повторение правил чтения и ударения. В последнем упражнении слова разделены на слоги, которые обозначены точками. Ударный слог выделен большой точкой. Для удобства аудиторного чтения абзацы текста пронумерованы. Под текстом указано количество содержащихся в нем печатных знаков и дан комментарий.

Вопросы к тексту составлены целенаправленно для обучения аннотированию текстов.

В систему упражнений входит перевод интернациональных слов без использования словаря, упражнения на словообразование и две программы лексики. Первая программа включает наиболее близкие по контексту синонимы или антонимы, вторая — глаголы в наиболее употребительном значении, наречия, служебные слова и выражения.

В конце каждого раздела предлагается система тестов, которые используются не только для контроля, но и как обучающее средство для эффективного запоминания терминологической и общетехнической лексики, знание которой необходимо для свободного чтения специальной литературы без словаря.

Тест первый предназначается для контроля усвоения специальной лексики и состоит из вопросов, после каждого из которых предлагается три варианта ответов. Требуется определить правильный вариант ответа.

Второй тест предназначен для контроля усвоения общей лексики и представляет собой группу английских слов и соответствующих им русских. Необходимо для каждого английского слова найти соответствующее русское значение.

Тест третий, основанный на принципах семантической группировки лексики (синонимия, антонимия), требует от обучающегося выбора синонима или антонима к подчеркнутому слову.

Тест четвертый представлен в виде неоконченных предложений, к каждому из которых предлагается три варианта его продолжения. Используя техническую информацию, полученную при чтении текстов данного раздела, необходимо правильно выбрать альтернативу и закончить предложение.

После тестов в конце раздела помещается текст. Тексты в разделах I, II, III, V, VI предназначаются для перевода без словаря, а в разделах IV, VII, IX — со словарем. В разделах I и II перед текстами помещены вопросы, которые ориентируют на извлечение определенной информации при чтении текста.

Разделы VIII—X рекомендуются для дополнительного чтения. Каждый раздел сопровождается тестом для контроля усвоения специальной и общей лексики и умения воспользоваться полученной технической информацией. Предлагается составить план к текстам раздела и написать по ним реферат.

Контроль за правильностью выполнения тестов, а также некоторых упражнений и текстов, помеченных звездочкой (*), осуществляется с помощью ключей, данных в конце пособия. Вопрос кодируется цифрой, а ответ — буквой. Образец выполнения тестов в письменной форме дан в конце первого раздела.

В приложение включены: список служебных слов и выражений, указания по чтению дробных числительных и математических знаков, краткий список сокращений и условных обозначений и словарь.

## Как работать над пособием

Необходима строгая последовательность изучения предлагаемого материала. Так как содержание разделов постепенно усложняется, к изучению каждого последующего раздела можно приступать только после полного усвоения предыдущих разделов и выполнения всех тестов.

Работе над каждым текстом должно предшествовать выполнение подготовительных упражнений, способствующих более успешному чтению и пониманию текста и усвоению лексики.

Последовательность работы над каждым разделом следующая:

1. Переведите интернациональные слова, не пользуясь словарем.

2. Переведите группы синонимов или антонимов. Даже одно знакомое вам слово в ряду поможет определить значение других слов, не обращаясь к словарю. Постарайтесь их запомнить.

3. Пользуясь словарем или списком служебных слов и выражений, переведите неизвестные вам глаголы или служебные слова и выражения.

**4. Выполните упражнения на словообразование.**

5. Отработайте произношение, стоящих перед текстом слов.

6. Прочтите текст. Читая, старайтесь сразу понять содержание. Добивайтесь слитного чтения, следите за правильностью ударения и интонации.

7. Переведите текст, если в этом есть необходимость.

8. Ответьте на вопросы к тексту.

9. На основании данных ответов составьте аннотацию или резюме прочитанного текста.

10. Внимательно проработав тексты одного раздела, проверьте себя на тестах. Если тесты вызывают затруднения в выборе правильной альтернативы, обратитесь снова к синонимам или антонимам и текстам соответствующих разделов и найдите правильный ответ. Тесты можно выполнять устно или письменно по форме, данной после тестов первого раздела.

11. Время от времени возвращайтесь к тестам ранее проработанных разделов. Проверяя себя, вы закрепите слабо усвоенную лексику. Ключами к программированным упражнениям следует пользоваться только для контроля правильности данного ответа или перевода.

Авторы выражают благодарность всем товарищам, оказавшим содействие в работе над данным учебным пособием.

*Авторы*

## SECTION ONE

### I.

### Pronunciation Drill 1

*Practise the vowels in the open syllable:*

| | | | | |
|---|---|---|---|---|
| nature | widely | use | extreme | probe |
| basis | device | tube | theme | remote |
| capable | define | huge | kilometer | motion |

*Practise the vowels in the closed syllable:*

| | | | | |
|---|---|---|---|---|
| plan | distant | industrial | enter | complex |
| expand | principle | conductor | hence | biology |
| advent | witness | puzzle | electron | rocket |

### Pronunciation Drill 2

*While reading these words pay attention to the stress markings*[1]*:*

| ● • | • ● | • ● • | ● • • |
|---|---|---|---|
| orbit | suggest | computer | national |
| mankind | ensure | designing | vehicle |
| decade | prepare | develop | calculate |

#### TEXT 1

## MODERN ELECTRONICS

1. Many scientists believe at present that mankind has entered the era of a new technological revolution which was brought about by the advent of cybernetics, whose ideas and methods found their way into virtually all branches of science and engineering, all the way from biology and medicine to economy and industrial management.

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[1] См. Предисловие, стр. 5.

2. Electronics is one of the main sciences, which forms the technological basis for using these new methods. Electronics studies the problems connected with the application of instruments and devices, the action of which is based on the utilization of various phenomena that result from the movement of electrons through vacuum, gases and solid bodies.

3. Electronics surrounds us everywhere. Television, tape-recording, radio-receiving—electronics is at the heart of them all. But that is only a small part of electronics and not the most important at that.[1] Extremely complicated electronic systems control the work of huge plants, enterprises and power stations. Electronic appliances are indispensable for planning and controlling our national economy.[2] Electronic computers are widely used in scientific research and industrial designing. Huge radio-telescopes, equipped with sensitive instruments and powerful amplifiers enable man to gain an insight into[3] the remotest corners of space, discover new and puzzling phenomena of nature.

4. Now mankind is in the second decade of the cosmic era. It was in 1957 that the first man-made satellite was launched in our country, and now man has already set his foot on the Moon, sends probes to distant planets and orbits the earth in space vehicles. All this could not have been done but for electronics.

5. Electronic computers calculate the trajectories of spaceships, help prepare, launch and monitor the rockets that carry the most complicated and sophisticated equipment. Radio-electronic systems ensure reliable communication with space probes at distances amounting to scores of millions of kilometres, relay relephotos of distant planets. Hundreds of electronic devices perform various tasks on board[4] every satellite and spaceship. It may be said that in the near future electronics will surely make great strides[5] and help the humanity gain new victories in science and engineering.

1 800

## Commentary

1. and not the most important at that — но не самая главная при этом

2. for planning and controlling our national economy — для планирования и управления народным хозяйством

3. to gain an insight into — проникнуть в

4. on board — на борту
5. electronics will surely make great strides — электроника, несомненно, сделает большие успехи

## EXERCISES

**I.** *Review questions:*

1. What was the result of the advent of cybernetics? 2. What is electronics? 3. What do electronic systems control? 4. Where are electronic computers used? 5. What enables man to gain an insight into the remotest corners of space? 6. When was the first man-made satellite launched? 7. In what way are electronic computers used in scientific space research? 8. What do radio-electronic systems ensure?

**II.** *Make up an abstract of the text basing on the answers to the above questions.*

**III.** *Translate the international words without a dictionary:*

idea, era, problem, computer, orbit, planet, satellite, rocket, basis, communication, cybernetics, trajectory, phenomenon, utilization, distance, nature, economy

**IV.** *Define the meanings of the suffixes in the following words and translate the words:*

scientist, electrician, engineer, computer, examinee, examiner, semiconductor, connection, equipment, discovery, reliability, appliance, existence, transmission, advantage, width, relationship, rapidness, launching, freedom

**V.** *Translate these synonyms and memorize them:*

1. big (*adj*), large, great, huge, enormous, vast
2. movement (*n*), motion
3. small (*adj*), tiny, little
4. main (*adj*), principal, chief
5. complex (*adj*), complicated, compound
6. many (*adj*), a lot of, plenty
7. basis (*n*), foundation, base
8. bring about (*v*), cause
9. perform (*v*), carry out
10. use (*v*), utilize, apply, employ

**VI.** *Translate these verbs and learn them:*

to enable, to result from, to believe, to launch, to equip, to discover, to connect, to form, to calculate, to surround

## II.

### Pronunciation Drill 1

*Practise the sound* [aɪ]:

type, widely, might, light, outside, apply, either, high, by, design, oxide, primary, collide, mind, kind, tiny, finally

### Pronunciation Drill 2

*While reading these words pay attention to the stress markings:*

| ● • | • ● | ● • • | • ● • |
|---|---|---|---|
| complex | surround | element | intensive |
| aspect | advance | everywhere | however |
| human | allow | afterwards | discover |

### TEXT 2

## FROM THE HISTORY OF ELECTRONICS

1. The realm of electronics of to-day influences almost every aspect of human activity, while it was only in the beginning of our century that the basic idea, which was to develop into one of the most astonishing sciences of our time, was conceived. It was our Russian scientist A. S. Popov, who discovered the principle of wireless communication that finally led to the development of electronic tubes for use in various communication devices.

2. In 1904 D. A. Flemming suggested a two-element tube (two-electrode tube), and in 1907 De Frost invented a three-electrode one. For a long time afterwards electronics was used only for the purpose of communication and for ensuring amplification and transformation of various signals in applied sciences.

3. Intensive development of radio-location began in the early forties. All these years the vacuum tube was the heart of electronics and, hence, the field of electronics was usually defined as the study of the motion of electrons in vacuum tubes. However, it was found that small, controlled quantities of gas introduced into a "vacuum tube" could make it perform switchings, rectifying and other jobs. To include the category of gas-filled tubes, "vacuum tubes" became convert-

ed to "electron tubes" and the science of electronics was expanded to include the study of electron motion in gases.

4. The first semiconductor triode was invented in 1948. It meant another important advance in the development of electronics. Semiconductors possess a number of valuable advantages over electron vacuum tubes, — miniature dimensions and high reliability. Thus electronics became the study of electron motion in solids. The realm of electronics widened still more. This opened up other fields of application for electronics.

5. The rapid growth of computer technology gave birth to[1] numerous types and models of electronic devices and computers, capable of performing highly complex mathematical calculations in a fraction of a second.

6. The last decade witnessed another stage in the development of electronics. Integrated circuits came into being.[2] Their application allowed engineers to reduce the dimensions of electronic devices and increase their reliability.

1800

### Commentary

1. The rapid growth of computer technology gave birth to — Быстрый рост вычислительной техники вызвал создание

2. came into being — появились

### EXERCISES

**I.** *Review questions:*

1. What finally led to the development of electronic tubes? 2. Who invented a two-electrode tube and a three-electrode one? 3. What kinds of jobs can gas-filled tubes perform? 4. When was the first semiconductor triode invented? 5. What advantages do semiconductors possess over electron vacuum tubes? 6. What did the application of integrated circuits allow engineers to do?

**II.** *Make up an abstract of the text basing on the answers to the above questions.*

**III.** *Translate the international words without a dictionary:*
type, aspect, principle, model, decade, technique, fraction, calculation, complex, intensive, miniature, category, electronic, technology, mathematical

**IV.** *Define what parts of speech these words are and translate them:*

important, different, various, valuable, powerful, powerless, scientific, technological, intensive, introductory, possible, produced

**V.** *Translate these synonyms and memorize them:*

1. include (*v*), involve, contain, comprise
2. convert (*v*), change, transform
3. basic (*adj*), fundamental
4. begin (*v*), start, commence
5. type (*n*), kind
6. numerous (*adj*), many
7. reduce (*v*), decrease
8. important (*adj*), significant
9. allow (*v*), permit, let
10. almost (*adv*), nearly

**VI.** *Translate these words and word combinations and learn them:*

finally, hence, however, at present, but for, through, extremely, already, widely, highly

## Test 1[1]

*Find the correct answer out of the three given to each question:*

1. Which of the following sciences forms the technological basis for cybernetics:
   mathematics, electronics, chemistry
2. Which of the devices is widely used in scientific research and industrial designing:
   a transformer, a motor, a computer
3. Which of the devices enabled man to gain an insight into the remotest corners of space:
   a huge radio-telescope, coloured TV, an electronic computer
4. Which of the following devices was the heart of electronics in the first half of this century:
   a gas-filled tube, a condenser, a vacuum tube
5. Which of the devices reduce the dimensions of electronic apparatus:
   vacuum tubes, integrated circuits, transistors

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[1] См. Предисловие, стр. 6

## Test 2

**I.** *Find Russian equivalents for the English verbs (see p. 147).*

| | |
|---|---|
| 1. connect | (a) окружать |
| 2. form | (b) верить, полагать |
| 3. discover | (c) вычислять |
| 4. believe | (d) давать возможность |
| 5. surround | (e) оборудовать |
| 6. result from | (f) открывать |
| 7. calculate | (g) запускать |
| 8. launch | (h) соединять |
| 9. enable | (i) являться результатом |
| 10. equip | (j) образовывать |

**II.** *Find Russian equivalents for the English words and word combinations (see p. ...):*

| | |
|---|---|
| 1. hence | (a) уже |
| 2. already | (b) через |
| 3. widely | (c) если бы не |
| 4. highly | (d) наконец |
| 5. however | (e) следовательно |
| 6. at present | (f) очень |
| 7. but for | (g) чрезвычайно |
| 8. through | (h) широко |
| 9. finally | (i) в настоящее время |
| 10. extremely | (j) однако |

**III.** *Match these synonyms (see p. 147):*

| | |
|---|---|
| 1. utilize | (a) huge |
| 2. many | (b) chief |
| 3. enormous | (c) transform |
| 4. principal | (d) compound |
| 5. contain | (e) begin |
| 6. change | (f) a lot of |
| 7. complicated | (g) use |
| 8. commence | (h) foundation |
| 9. base | (i) little |
| 10. tiny | (j) comprise |

## Test 3

*Find a synonym (a), (b), (c) or (d) to the word or word combination in bold type:*

1. A **large** area — (a) small; (b) vast; (c) entire; (d) little
2. **Complex** structure — (a) unknown; (b) simple; (c) complicated; (d) important

3. The **motion** of electrons — (a) loss; (b) number; (c) movement; (d) attraction

4. **A lot of** tubes — (a) plenty; (b) few; (c) two; (d) some

5. A **basic** subject — (a) difficult; (b) easy; (c) interesting; (d) fundamental

6. To **perform** the same function — (a) follow; (b) have; (c) mean; (d) carry out

7. To **transform** an electric current — (a) transmit; (b) measure; (c) use; (d) convert

8. To be **nearly** the same — (a) sometimes; (b) almost; (c) usually; (d) always

9. The same **kinds** of devices — (a) applications; (b) sizes; (c) types; (d) models

10. The **numerous** experiments — (a) different; (b) easy; (c) some; (d) many

11. To **use** a vacuum tube — (a) develop; (b) invent; (c) apply; (d) buy

12. The **main** idea — (a) new; (b) old; (c) good; (d) principal

13. The technological **basis** — (a) foundation; (b) process; (c) revolution; (d) method

14. To **permit** the transmission of the electrons — (a) stop; (b) allow; (c) limit; (d) use

15. The **important** problem — (a) difficult; (b) interesting; (c) significant; (d) new

16. To **decrease** the temperature — (a) reduce; (b) increase; (c) measure; (d) change

17. A **small** portion — (a) similar; (b) common; (c) tiny; (d) great

18. The problem **includes** — (a) leads; (b) enables; (c) means; (d) involves

19. To **begin** the experiment — (a) use; (b) make; (c) study; (d) start

20. A new technological revolution was **brought about** — (a) developed; (b) spoken about; (c) caused; (d) based

## Test 4

*Finish each sentence choosing one of the three variants (a), (b) or (c) based on the texts from Section I:*

Instructions:

For example:

1. The texts of Section 1 are about ...

(a) energetics; (b) electronics; (c) cybernetics.

Phrase marked (b) is correct. Write down letter (b) on the answer sheet, like this: 1. (b)

1. Many scientists believe that a new technological revolution was brought about by...
   (a) chemical sciences; (b) cybernetics; (c) mathematics.
2. Electronics as a science appeared...
   (a) a century ago; (b) in the early fifties; ((c) at the beginning of our century.
3. The first manned spaceship was launched in...
   (a) 1963; (b) 1961; (c) 1959.
4. The first man-made moon was launched...
   (a) in the forties; (b) at the beginning of the twentieth century; (c) in the second half of the twentieth century.
5. The first man-made satellite was launched in...
   (a) 1959; (b) 1957; (c) 1961.
6. Electronics involved the study of the problems connected with the movement of...
   (a) electrons; (b) molecules; (c) atoms.
7. The transistor was developed...
   (a) five years ago; (b) in nineteen forty-eight; (c) in the early forties.
8. The principle of wireless communication was discovered by...
   (a) Popov; (b) Edison; (c) Bohr.
9. A two-element tube was suggested by...
   (a) Dalton; (b) Newton; (c) Flemming.
10. A two-electrode tube was invented...
    (a) in recent years; (b) at the beginning of this century; (c) last year.
11. De Frost suggested...
    (a) a three-electrode tube; (b) a two-electrode tube; (c) the first semiconductor device.
12. De Frost invented a three-electrode tube...
    (a) last century; (b) in the fifties; (c) in nineteen 0 seven.
13. Gas-filled tubes include the study of electron motion in...
    (a) liquids; (b) solids; (c) gases.
14. In the middle of this century another important advance in the development of electronics was the invention of...
    (a) gas-filled tubes; (b) vacuum tubes; (c) semiconductors.

15. With the invention of semiconductors electronics became the study of electron motion in...
    (a) solids; (b) liquids; (c) gases.
16. Semiconductors possess a number of valuable advantages over...
    (a) incandescent lamps; (b) electron vacuum tubes, (c) gas-filled tubes.
17. Semiconductors are distinguished for their...
    (a) large dimensions; (b) low reliability; (c) miniature dimensions and high reliability.
18. The principal parts of the computer are...
    (a) electric circuits; (b) electronic devices; (c) sources of the alternating signals.
19. Electronic computers...
    (a) perform highly complex mathematical calculation in a fraction of a second; (b) perform only simple mathematical calculations; (c) are widely used for different kinds of measuring.
20. The application of integrated circuits allowed engineers...
    (a) to decrease the dimensions and reliability of electronic devices; (b) to increase the dimensions and reliability of electronic devices; (c) to reduce the dimensions of electronic devices and increase their reliability.

(*See keys to the tests on p. 147.*)

## Answer Sheet

**Test 1:** 1.—; 2.—; 3.—; 4.—; 5.—
**Test 2. I:** 1.—; 2.—; 3.—; 4.—; 5.—; 6.—; 7.—; 8.—; 9.—; 10.—
**II:** 1.—; 2.—; 3.—; 4.—; 5.—; 6.—; 7.—; 8.—; 9.—; 10.—
**III:** 1.—; 2.—; 3.—; 4.—; 5.—; 6.—; 7.—; 8.—; 9.—; 10.—
**Test 3:** 1.—; 2.—; 3.—; 4.—; 5.—; 6.—; 7.—; 8.—; 9.—; 10.—; 11.—; 12.—; 13.—; 14.— 15.—; 16.—; 17.—; 18.—; 19.—; 20.—
**Test 4:** 1.—; 2.—; 3.—; 4.—; 5.—; 6.—; 7.—; 8.—; 9.—; 10.—; 11.—; 12.—; 13.—; 14.—; 15.—; 16.—; 17.— ;18.—; 19.—; 20.—

N o t e : Instead of dashes write down your answer in the form of a word (e.g. Test 1. 1. electronics; 2.—; 3.—, etc.) or in the form of a needed letter (e.g. Test 2. I: 1. (h); 2.—, 3.—, etc.)

*After reading the following text be ready to answer these questions.*

1. What station was launched in 1970 in the Soviet Union? 2. What was the purpose of the flight? 3. What equipment

was installed (установлено) aboard the vehicle? 4. How was the movement of the automatic station controlled?

TEXT

1. On November 10th, 1970, the Luna 17 automatic station was launched in the Soviet Union. The purpose of the flight was the perfection (усовершенствование) of the new systems, carried by the station and the further scientific study of the Moon and near-Moon space.

2. The Luna 17 automatic station landed on the surface of the Moon on November 17th, 1970. An automatic lunar vehicle has been placed on the Moon for the first time in the history of cosmonautics. Flags and pennants (вымпелы) with the image of the state emblem of the USSR and a basrelief portrait of Lenin were installed (установлены) on the Lunokhod 1 and on the landing stage.

3. The self-propelled (самоходный) vehicle was equipped with scientific apparatus and instruments, and control radio communication and TV observation systems for research operations on the Moon at different distances from the place of landing. A French laser reflector had been installed aboard the Lunokhod 1 according to the Soviet-French agreement (соглашение) on cooperation.

4. The movement of the Lunokhod 1 was controlled from the centre of long-distance space communications utilizing the TV information. The successful work of the 1st world self-propelled automatic station Lunokhod 1 lasted 10 months and a half. During its stay on the Moon the vehicle covered the distance of 10,540 meters. With the help of the scientific radio-electronic equipment installed on board the Lunokhod 1 more than 20,000 panoramic pictures of the lunar surface were taken and transmitted to Earth and other valuable scientific information was received. The highly complicated radio-electronic equipment ensured the transmission of various information to Earth concerning the physical conditions on the surface of our satellite.

## SECTION TWO

### Pronunciation Drill 1

*Practise the sound* [ɔ:]:

also, always, already, small, almost, although, thought, all, important, more, four, ball, orbit, force, call, brought,

portion, saw, ordinary, orderly, alternating, audio, source, cause, fall

### Pronunciation Drill 2

*While reading these words pay attention to the stress markings.*

| ● • | ● •• | • ● • | • ● • • |
|---|---|---|---|
| process | carrier | emitter | sufficiently |
| method | barrier | electrode | inadequate |
| metal | energy | enable | available |
| unit | quantity | important | majority |

### TEXT 3

## ELECTRON EMISSION

1. The electron tube depends for its action on a stream of electrons that act as current carriers. To produce this stream of electrons a special metal electrode (cathode) is present in every tube. But at ordinary room temperatures the free electrons in the cathode cannot leave its surface because of certain restraining forces that act as a barrier. These attractive surface forces tend to keep the electrons within the cathode substance, except for a small portion that happens to have sufficient kinetic energy (energy of motion) to break through the barrier. The majority of electrons move too slowly for this to happen.

2. To escape from the surface of the material the electrons must perform a certain amount of work to overcome the restraining surface forces. To do this work the electrons must have sufficient energy imparted to them from some external source of energy, since their own kinetic energy is inadequate. There are four principal methods of obtaining electron emission from the surface of the material: thermionic emission, photoelectric emission, field emission and secondary emission.

3. **Thermionic emission.** It is the most important and one most commonly used in electron tubes. In this method the metal is heated, resulting in increased thermal or kinetic energy of the unbound electrons. Thus, a greater number of electrons will attain sufficient speed and energy to escape from the surface of the emitter. The number of electrons released per unit area of an emitting surface is related to the absolute temperature of the cathode and a quantity of the

work an electron must perform when escaping from the emitting surface.

4. The thermionic emission is obtained by heating the cathode electrically. This may be produced in two ways: 1. by using the electrons emitted from the heating spiral for the conduction of current (direct heating) or 2. by arranging the heating spiral in a nickel cylinder coated with barium oxide which emits the electrons (indirect heating). Normally, the method of indirect heating is used.

5. **Photoelectric emission.** In this process the energy of the light radiation falling upon the metal surface is transferred to the free electrons within the metal and speeds them up sufficiently to enable them to leave the surface.

6. **Field or cold-cathode emission.** The application of a strong electric field (i.e. a high positive voltage outside the cathode surface) will literally pull the electrons out of the material surface, because of the attraction of the positive field. The stronger the field, the greater the field emission from the cold emitter surface.

7. **Secondary emission.** When high-speed electrons suddenly strike a metallic surface they give up their kinetic energy to the electrons and atoms which they strike. Some of the bombarding electrons collide directly with free electrons on the metal surface and may knock them out from the surface. The electrons freed in this way are known as secondary emission electrons, since the primary electrons from some other source must be available to bombard the secondary electron-emitting surface.

2600

## EXERCISES

I. *Review questions:*

1. What does the action of the electron tube depend on? 2. What is present in every tube to produce the stream of electrons? 3. At what temperatures free electrons cannot leave their surface of the cathode? 4. What forces tend to keep the electrons within the cathode substance? 5. What must the electrons do to escape? 6. What must the electrons have to overcome the restraining surface forces? 7. How many methods are there for obtaining electron emission? 8. What are they? 9. What imparts the external energy to the electrons in thermionic emission? 10. What energy is used for producing free electrons in photoelectric emission? 11. What is field emission? 12. How is secondary emission obtained? 13. What emission is the most commonly used in electronics?

**II.** *Make up an abstract of the text basing on the answers to the above questions.*

**III.** *Translate the international words without a dictionary.*
cathode, emitter, material, cylinder, portion, energy, radiation, temperature, thermal, adequate, absolute, special, emission, electron, normally

**IV.** *Define to what parts of speech these words belong and translate them:*
realize, equalize, electrify, classify, originate, strengthen, widen, increasingly, widely, likewise, otherwise, forward, towards, upward, outward, downward

**V.** *Translate these antonyms and memorize them:*
1. be present (*v*), be absent
2. primary (*adj*), secondary
3. relative (*adj*), absolute
4. outside (*adj*), inside
5. majority (*n*) minority
6. common (*adj*), special
7. external (*adj*), internal
8. slow (*adj*), quick, rapid
9. free (*adj*), bound
10. strong (*adj*), weak

**VI.** *Translate these words and word combinations and learn them:*
because of, since, except for, a number of, the same, within, in this way, suddenly, sufficiently, literally

## Test 1

*Find the correct answer out of the three given to each question:*

1. Which of the following devices depends for its action on a stream of electrons in vacuum:
   a gas tube, an electron tube, a transistor
2. Which of the following forces keep the electrons within the emitter substance:
   internal forces, external forces, attractive surface forces
3. Which of the following kinds of emission depends on increased thermal energy of electrons:
   thermionic emission, secondary emission, field emission
4. Which of the following kinds of emission depends on a strong field:

thermionic emission, field emission, photoelectric emission

5. Which of the methods of emission is the most important and widely used:
field emission, thermionic emission, photoelectric emission

## Test 2

*Find Russian equivalents for the English words and word combinations (see p. 147):*

| | |
|---|---|
| 1. a number of | (a) буквально |
| 2. except for | (b) тот же самый |
| 3. literally | (c) так как; с тех пор как; с |
| 4. suddenly | (d) из-за |
| 5. within | (e) достаточно |
| 6. in this way | (f) внезапно |
| 7. since | (g) за исключением |
| 8. the same | (h) ряд |
| 9. because of | (i) таким образом |
| 10. sufficiently | (j) внутри; в; в пределах |

## Test 3

*Find an antonym (a), (b), (c) or (d) to the word in bold type:*

1. The **primary** question — (a) principal; (b) difficult; (c) secondary; (d) new
2. A **slow** motion of electrons — (a) similar; (b) rapid; (c) steady; (d) continuous
3. The **internal** forces — (a) attractive; (b) strong; (c) restraining; (d) external
4. A **small** portion — (a) great; (b) similar; (c) external; (d) common
5. A **high** speed — (a) decreased; (b) low; (c) adequate; (d) sufficient
6. The **strong** attractive forces — (a) slight; (b) equal; (c) unequal; (d) weak
7. **Outside** the tube — (a) near; (b) in front of; (c) inside; (d) around
8. **Cold** water — (a) clean; (b) hot; (c) boiled; (d) mineral
9. To **heat** the liquid — (a) boil; (b) change; (c) evaporate; (d) cool
10. The **majority** of the electrons — (a) a great number of; (b) weight; (c) minority; (d) amount

11. **Common** measuring devices — (a) various; (b) necessary; (c) special; (d) new

12. The flow is **rapidly** determined — (a) often; (b) commonly; (c) frequently; (d) slowly

13. **Many** particles — (a) light; (b) few; (c) free; (d) heavy

14. To **be present** in this tube — (a) be included; (b) be inclosed; (c) be changed; (d) be absent

15. **Free** particles — (a) small; (b) bound; (c) loose; (d) tiny

16. **Absolute** temperature — (a) high; (b) low; (c) relative; (d) the same

17. **More** interested in — (a) usually; (b) always; (c) never; (d) less

18. **Negative** charges — (a) the same; (b) unlike; (c) different; (d) positive

19. **Large** particles — (a) a lot of; (b) various; (c) tiny; (d) great

20. In a **downward** direction — (a) upward; (b) outward; (c) straight; (d) right

## Test 4

*Finish each sentence choosing one of the three variants (a), (b) or (c) based on the text from Section II:*

1. The electron tube depends for its action on...
   (a) restraining forces; (b) a stream of electrons; (c) a magnetic field.
2. A special metal electrode is present in every tube to produce...
   (a) a magnetic field; (b) a stream of positive charges; (c) a stream of electrons.
3. At ordinary room temperatures the "free" electrons in the metallic cathode cannot leave its surface because of...
   (a) attractive forces acting as a barrier; (b) forces of the external magnetic field; (c) thermal energy of the atoms.
4. A small portion of electrons has sufficient kinetic energy to break through...
   (a) the surface of the tube; (b) the plate substance; (c) the surface barrier.
5. To escape from the surface of the cathode the electrons must have...
   (a) attractive internal force; (b) sufficient energy from some external energy source; (c) low speed.

6. The energy for electron emission comes from...
   (a) internal sources; (b) external sources; (c) external and internal sources.
7. There are...
   (a) two principal methods of obtaining electron emission; (b) three principal methods of obtaining electron emission; (c) four principal methods of obtaining electron emission.
8. The cathode metal is heated in...
   (a) photoelectric emission; (b) cold-cathode emission; (c) thermionic emission.
9. In thermionic emission the cathode is made of...
   (a) metal; (b) semiconductor; (c) an insulator.
10. In thermionic emission the number of released electrons depends on...
   (a) resistance; (b) cooling; (c) temperature.
11. In photoelectric emission the energy of the light falls...
   (a) upon the surface of the non-conducting material; (b) into the glass envelope filled with the gas; (c) upon the surface of the metal.
12. In photoelectric emission the energy of the light radiation is transferred to...
   (a) free electrons; (b) bound particles; (c) positive charges.
13. In photoelectric emission electrons to which the energy of the light radiation is transferred are...
   (a) on the surface of the metal; (b) in the space about the cathode; (c) within the metal.
14. Field emission is...
   (a) hot-cathode emission; (b) photoelectric emission; (c) cold-cathode emission.
15. Electrons escape from the cathode surface because of...
   (a) the attraction of the positive field; (b) the attraction of the negative field; (c) the cooling of the cathode's metal.
16. When high-speed electrons suddenly strike a metallic surface they give up their kinetic energy to...
   (a) electrons; (b) positive particles; (c) positive charges.
17. Some of the bombarding electrons collide directly with...
   (a) positively charged particles; (b) uncharged particles; (c) free electrons.
18. From the surface the bombarding electrons may knock out...

(a) uncharged particles; (b) free electrons; (c) positive charges.

19. The electrons freed by bombarding are known as...
(a) secondary emission electrons; (b) thermionic emission electrons; (c) photoelectric emission electrons.

20 The most important and the most commonly used method of emission is...
(a) secondary emission; (b) field emission; (c) thermionic emission.

(*See keys to the tests on p. 147.*)

*After reading the following text be ready to answer these questions:*

1. How many methods are there for heating cathodes? 2. Where to is the electric current applied in the direct method? 3. Where to is the electric current applied in the indirect method? 4. What materials are used for cathodes? 5. What current can be used for heating them?

## TEXT

1. Cathodes are heated electrically either directly or indirectly. In the direct method, the electric current is applied directly to a wire, called filament, that also serves as an electron emitter.

2. In the indirect method the electric current is applied to a separate heater element, located inside a cylinder that is coated with the emitting material. The cathode is thus heated indirectly through heat transfer (трансформатор накала) from the heater element. Alternating or direct current can be used for both methods of heating.

3. The most commonly used materials for cathodes are tungsten (вольфрам), heated to temperatures between 2000° and 2800° C, thoriated tungsten (торированный вольфрам) operated at about 1700° C and oxide-coated cathodes operated at about 800° to 1000° C. Most tubes are indirectly heated.

## SECTION THREE

### I.

### Pronunciation Drill 1

*Practise the sound* [ou]:

both, diode, envelope, low, most, close, below, only, show, know, known, though, coat, control, whole, process, hollow, flow, follow, cathode, motion, cold, glow, photo-tube

### Pronunciation Drill 2

*While reading these words pay attention to the stress markings:*

| ● • | ● • • | • ● • | • ● • • |
|---|---|---|---|
| certain | constitute | external | eventual |
| circuit | actual | electron | phenomenon |
| follow | difference | determine | evacuate |
| either | envelope | collector | replenishing |

#### TEXT 4

### DIODES

1. The simplest combination of elements constituting an electron tube is the diode. It consists of a cathode, which serves for emitting the electrons, and a plate or anode surrounding the cathode, which acts as a collector of electrons. Both electrodes are enclosed in a highly evacuated envelope of glass or metal. If the cathode is indirectly heated, there must be a heating spiral or a heater. The size of diode tubes varies from tiny metal tubes to large-sized rectifiers. The plate is generally a hollow metallic cylinder made of nickel, molybdenum graphite, tantalum or iron.

2. A basic law of electricity states that like charges repel each other and unlike charges attract each other. Electrons emitted from the cathode of an electron tube are negative electric charges. These charges may be either attracted to or repelled from the plate of a diode tube, depending on whether the plate is positively or negatively charged.

3. Actually, by applying a potential difference (voltage) from a battery or other source between the plate and cathode of a diode, an electric field is established within the tube.

The lines of force of this field always extend from the negatively charged element to the positively charged element. Electrons, being negative electric charges, follow the direction of the lines of force in an electric field.

4. By establishing an electric field of the correct polarity between cathode and plate and "shaping" the lines of force of this field in certain paths,[1] the motion of the electrons can be controlled as desired. A battery is connected between plate and cathode of a diode, so as to make the plate positive with respect to the cathode, the lines of force of the electric field extending in a direction from the cathode to the plate.

5. Again, applying a heater voltage results in emission of electrons from the cathode. The electrons follow the lines of force to the positive plate and strike it at high speed. Since moving charges comprise an electric current, the stream of electrons to the plate is an electric current, called the plate current.

6. Upon reaching the plate the electron current continues to flow through the external circuit made up of the connecting wires and the battery. The arriving electrons are absorbed into the positive terminal of the battery and an equal number of electrons flow out from the negative battery terminal and return to the cathode, thus replenishing the supply of electrons lost by emission.

7. As long as the cathode of the tube is maintained at emitting temperatures and the plate remains positive, plate current will continue to flow from the cathode to the plate within the tube and from the plate back to the cathode through the external circuit.

8. Now a battery connection has been reversed so as to make the plate negative with respect to the cathode. When voltage is applied to the heater the cathode will emit a flow of electrons. However, these electrons are strongly repelled from the negatively charged plate and tend to fill the interelectrode space between cathode and plate. Since no electrons actually reach the plate, the tube acts like an open circuit.

9. The total number of electrons emitted by the cathode of a diode is always the same at a given operating temperature. The plate voltage (voltage between plate and cathode) has no effect, therefore, on the amount of electrons emitted from the cathode. Whether or not these electrons actually reach the plate, however, is determined by the plate-to-cathode voltage,[2] as well as by a phenomenon known as space charge.

10. The term space charge is applied to the cloud of electrons that is formed in the interelectrode space between cathode and plate. Since it is made up of electrons, this cloud constitutes a negative charge in the interelectrode space that has a repelling effect on the electrons being emitted from the cathode. The effect of this negative space charge alone, therefore, is to force a considerable portion of the emitted electrons back into the cathode and prevent others from reaching the plate.

11. The space charge, however, does not act alone. It is counteracted by the electric field from the positive plate, which reaches through the space charge to attract electrons and thus partially overcomes its effects. At low positive plate voltages only electrons nearest to the plate are attracted to it and constitute a small plate current. The space charge then has a strong effect on limiting the number of electrons reaching the plate.

12. As the plate voltage is increased, a greater number of electrons are attracted to the plate through the negative space charge and correspondingly fewer are repelled back to the cathode. If the plate voltage is made sufficiently high, a point is reached eventually, where all the electrons emitted from the cathode are attracted to the plate and the effect of the space charge is completely overcome. Further increases in the plate voltage cannot increase the plate current through the tube, and the emission from the cathode limits the maximum current flow.

4000

## Commentary

1. "shaping" the lines of force of this field in certain paths — придавая силовым линиям определенные направления

2. whether or not these electrons actually reach the plate, however, is determined by the plate-to-cathode voltage — однако попадание или непопадание электронов на анод определяется анодным напряжением

## EXERCISES

I. *Review questions:*

1. What elements does a diode consist of? 2. What metal is the plate made of? 3. What does a basic law of electricity state? 4. What charges are emitted from the cathode of an electron tube? 5. When is an electric field established within

the tube? 6. For what purpose is a battery connected between the plate and the cathode of a diode? 7. What is the plate current? 8. When does the tube act like an open circuit? 9. What is space charge? 10. What is the effect (action) of the space charge?

**II.** *Make up an abstract of the text basing on the answers to the above questions.*

**III.** *Translate the international words without a dictionary:*
to vary, to control, to absorb, to indicate, to tend, to limit, to discuss, to form

**IV.** *Define what parts of speech these words are and translate them:*
direction, directive, directly, indirectly, director; partial, partially, partly, party; operator, operating, operation, operative, operatively; converter, convertible; dependable, dependent, dependence, dependency

**V.** *Translate these antonyms and memorize them:*
1. remain (*v*), leave
2. correct (*adj*), wrong
3. simple (*adj*), complicated
4. continue (*v*), interrupt
5. lose (*v*), gain
6. attract (*v*), repel
7. stop (*v*), start
8. strongly (*adv*), weakly
9. externally (*adv*), internally
10. open (*adj*), closed

**VI.** *Translate these words and word combinations and learn them:*
both, whether ... or, each other, with respect to, as long as, generally, eventually, therefore, correspondingly, as well as

## II.

### Pronunciation Drill 1

*Practise the sound* [au]:
how, without, now, however, ground, power, outside, output, around, about, found, encounter, amount, surround, bound, profound

## Pronunciation Drill 2

*While reading these words pay attention to the stress markings:*

| | | |
|---|---|---|
| total | discuss | specific |
| constant | obtain | effective |
| voltage | between | attraction |

### TEXT 5

## DIODE CHARACTERISTICS

1. The relation between the plate current in a diode and the plate-to-cathode voltage just discussed can be represented by a characteristic curve, obtained by plotting the plate-current $I_a$ values for different values of the applied plate voltage $E_a$.

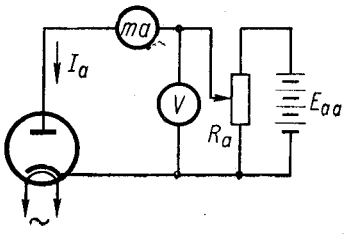


Fig. 1. Circuit arrangement for determination of the characteristics of a diode

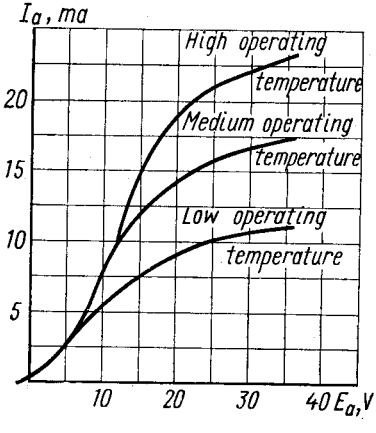


Fig. 2. Diode characteristic plate current-plate voltage curves

2. The diode the characteristic of which is to be determined is connected in circuit in the manner shown in Fig. 1. Heating voltage and heating current are kept constant while the tube characteristic is being obtained. Plate current is being increased by steps by adjusting the variable resistor $R_a$ connected in the same way as a potential divider. The anode current and voltage are indicated.

3. The diode characteristics for a typical diode tube and various cathode operating temperatures are shown in Fig. 2.

It is seen from Fig. 2 that all the curves are the same at low plate voltages, where the negative space charge is most effective in limiting the flow of electrons. The plate current in the low plate-voltage region is completely controlled by the voltage at the plate and

is independent of the cathode temperature. Under these conditions the plate current is said to be space-charge limited.

4. As the plate voltage is made progressively higher, an increasingly greater portion of the total supply of emitted electrons are attracted to the plate and the effect of the space charge is eventually completely overcome. This is seen by the flattening of the charateristic curves, as the plate voltage is increased. When the entire supply of emitted electrons at a given cathode temperature is attracted to the plate, the plate current becomes independent of the plate voltage and reaches a constant value equal to the total emission current. Emission saturation takes place and the plate current is said to be emission-limited in the high plate-voltage region.[1] The foregoing has already made it clear that the principal advantage of the diode tube is that it permits the flow of current in one direction only, that is from the cathode to the anode. For this reason diode tubes are often used as rectifiers to change alternating current to direct current.

1700

## Commentary

1. Emission saturation takes place and the plate current is said to be emission-limited in the high plate-voltage region. — Происходит эмиссионное насыщение и считается, что анодный ток достигает насыщения в области высоких напряжений

### EXERCISES

**I.** *Review questions:*

1. What does a diode characteristic show? 2. What is kept constant while the tube characteristic is being obtained? 3. What controls the plate current in the low plate-voltage region? 4. What is independent of the cathode temperature? 5. Under what conditions is the plate current said to be space-charge limited? 6. When does the emission saturation take place? 7. Why are the diode tubes used as rectifiers? 8. What current do they rectify?

**II.** *Make up an abstract of the text basing on the answers to the above questions.*

**III.** *Translate the international words without a dictionary:* anode, diode, effect, characteristic, constant, total

**IV.** *Define the meanings of the prefixes in the following words and translate the words:*

abnormal, misdirection, unheated, interchange, overload, irregular, reconvert, dissimilar, non-effective, impossible, illegal, independence, co-operate, subdivide, semicircle, supernatural, self-determination, post-war, pre-war, underlie, foregoing, neo-realism

**V.** *Translate these antonyms and memorize them:*

1. best (*adj*), worst
2. constant (*adj*), variable
3. never (*adv*), always
4. increase (*v*), decrease
5. obtain (*v*), lose
6. take (*v*), give
7. different (*adj*), similar
8. normally (*adv*), abnormally
9. partial (*adj*), total
10. many (*adj*), few

**VI.** *Translate these verbs and learn them:*

to take place, to become, to determine, to depend on (upon), to reach, to represent, to overcome, to establish, to follow, to fill

## Test 1

*Find the correct answer out of the three given to each question:*

1. Which of the following tubes consists of a cathode and a plate:
   a triode tube, a diode tube, a tetrode tube
2. Which of the following charges repel each other:
   like charges, unlike charges, positive and negative charges
3. Which of the following charges are emitted from the cathode of an electron tube:
   unlike charges, positive charges, negative charges
4. Which of the following charges in respect to the cathode must have an anode to transmit the direct current:
   positive charges, negative charges, neutral charges
5. Which of the following is established within the tube by applying a potential difference:
   an electric field, ionization, de-ionization

## Test 2

**I.** *Find Russian equivalents for the English words and word combinations (see p. 147):*

| | |
|---|---|
| 1. as well as | (a) или ... или |
| 2. both | (b) относительно, в отношении |
| 3. whether ... or | (c) в конце концов |
| 4. with respect to | (d) оба |
| 5. therefore | (e) друг друга |
| 6. as long as | (f) вообще, обычно |
| 7. eventually | (g) соответственно |
| 8. each other | (h) а также и |
| 9. correspondigly | (i) поэтому |
| 10. generally | (j) пока |

II. *Find Russian equivalents for the English verbs (see p. 32):*

| | |
|---|---|
| 1. reach | (a) происходить |
| 2. follow | (b) становиться |
| 3. take place | (c) устанавливать |
| 4. become | (d) достигать |
| 5. fill | (e) следовать |
| 6. establish | (f) преодолевать |
| 7. overcome | (g) представлять, изображать |
| 8. depend on (upon) | (h) определять |
| 9. represent | (i) наполнять(ся) |
| 10. determine | (j) зависеть от |

## Test 3

*Find an antonym (a), (b), (c) or (d) to the word in bold type:*

1. To **attract** electrons — (a) produce; (b) conduct; (c) repel; (d) lose

2. To **stop** the plate current — (a) measure; (b) transfer; (c) convert; (d) start

3. **Closed** circuits — (a) open; (b) internal; (c) external; (d) different

4. A **constant** value — (a) high; (b) variable; (c) low; (d) abnormal

5. A **simple** structure — (a) heavy; (b) light; (c) complicated; (d) modern

6. To **increase** the stream of electrons — (a) obtain; (b) decrease; (c) change; (d) stop

7. The **best** method — (a) unknown; (b) main; (c) worst; (d) principal

8. The electrons are **strongly** repelled — (a) weakly; (b) never; (c) always; (d) quickly

9. To be connected **externally** — (a) indirectly; (b) directly; (c) strongly; (d) internally

10. This value **never** decreases — (a) sometimes; (b) normally; (c) always; (d) often

11. **Similar** problems — (a) well-known; (b) different; (c) important; (d) quite understandable

12. To **lose** strength — (a) depend on; (b) limit; (c) gain; (d) determine

13. A **correct** answer — (a) wrong; (b) good; (c) bad; (d) clever

14. The process is **continued** — (a) started; (b) changed; (c) interrupted; (d) finished

15. The **same** conductors — (a) different; (b) bad; (c) good; (d) similar

16. When it **remains** — (a) starts; (b) gives; (c) leaves; (d) works

17. To **give** an idea — (a) discuss; (b) simplify; (c) take; (d) understand

18. The **total** supply of electrons — (a) steady; (b) partial; (c) constant; (d) continuous

19. It can be **obtained** — (a) made; (b) measured; (c) controlled; (d) lost

20. It is **normal** that — (a) said; (b) known; (c) abnormal; d) found

## Test 4

*Finish each sentence choosing one of the three variants (a). (b) or (c) based on the texts from Section III:*

1. The diode is...
   (a) the simplest combination of elements constituting an electron tube; (b) the most complicated combination of elements constituting an electron tube; (c) a tube with three electrodes.
2. A diode consists of ...
   (a) an anode alone; (b) a cathode alone; (c) a cathode and a plate.
3. The cathode serves as...
   (a) a collector of electrons; (b) a source of electrons; (c) a source of positive particles.
4. The anode serves as...
   (a) a source of electrons; (b) a collector of electrons; (c) a source of uncharged particles.
5. A basic law of electricity states that...
   (a) like charges repel each other; (b) like charges attract each other; (c) unlike charges repel each other.

6. Electrons emitted from the cathode of an electron tube are...

(a) positive electric charges; (b) positively charged particles; (c) negative electric charges.

7. An electric field is established by applying to the electrodes...

(a) heating energy; (b) a potential difference; (c) light energy.

8. Electron current flows in the diode only when...

(a) the plate is made negative; (b) the plate is made positive; (c) the plate has no charges.

9. Electron current flows in the diode only when...

(a) the cathode is made positive; (b) the cathode has no charges; (c) the cathode is made negative.

10. At a given operating temperature the total number of electrons emitted by the cathode of a diode is always...

(a) different; (b) the same; (c) increasing.

11. The cloud of electrons formed in the space between the cathode and the plate is called...

(a) a space charge; (b) an interelectrode space; (c) a positive external charge.

12. The space charge is...

(a) negative; (b) positive; (c) neutral.

13. The space charge has...

(a) an attracting effect on electrons; (b) no effect at all; (c) a repelling effect on electrons.

14. The flow of electrons to plate is an electric current called...

(a) an alternating current; (b) an internal current; (c) a plate current.

15. The amount of plate current depends on...

(a) the interelectrode space; (b) the space charge; (c) the negative plate voltage.

16. The plate current is space-charge limited when...

(a) at low plate voltage the negative space charge limits the flow of electrons; (b) the plate current reaches saturation at high plate voltage; (c) the negative space charge has an attracting effect on electrons.

17. The plate current is said to be emission-limited in the high plate-voltage region when...

(a) the plate current has variable value; (b) the emitted electrons are repelled from the plate; (c) the emission saturation takes place.

18. In general, electron tubes are operated in...

(a) the high plate-voltage region; (b) the space-charge limited region; (c) the saturation region.

19. The principal advantage of the diode tube is that it permits the flow of current in...

(a) one direction only; (b) two directions; (c) no direction.

20. The diode tubes are often used as...

(a) stabilizers; (b) amplifiers; (c) rectifiers.

*(See keys to the tests on p. 147.)*

*Translate into Russian without a dictionary:*

TEXT

1. A diode is a two-element electron tube that consists of a cathode and an anode or plate acting as an electron collector. By applying a positive voltage to the plate of a diode, an electric field is established between cathode and plate that attracts electrons emitted from the cathode to the plate.

2. Plate current is the flow of electrons from cathode to the plate and their return to the cathode through the external circuit. Plate current flows in a diode when the plate is made positive with respect to the cathode. No current flows when the plate is negative with respect to the cathode. This is called unidirectional conduction.

3. The cloud of electrons formed in the space between cathode and the plate is called space charge. The space charge is negative and hence has a repelling effect on electrons emitted from the cathode. The amount of the plate current depends on the space charge and the relative strength of the electric field set up (создаваемого) by the positive plate voltage.

4. At low plate voltages the negative space charge limits the flow of electrons and the plate current is completely controlled by the plate voltage and is independent of cathode temperature. The plate current is space-charge limited. At high plate voltages the space charge is drawn off (исчезает) and the plate current reaches saturation at a value equal to the total emission current. It is then independent of the plate voltage and is said to be emission-limited for a specific cathode temperature. As the diode tube permits the flow of

current in one direction only it is often used as a rectifier to change alternating current to direct current.

1400

## SECTION FOUR

### I.

### Pronunciation Drill 1

*Practise the sound* [ju: ]:

tube, value, use, knew, produce, utilize, few, unit, neutralise, suitable, accumulate, usual, view, new

*Practise the sound* [ju ]:

eventually, vacuum, simulate, actually, manufacture, virtually

### Pronunciation Drill 2

*While reading these words pay attention to the stress markings:*

| • ● | ● • | • ● • | ● • • |
|---|---|---|---|
| desire | tiny | alternate (*adj*) | alternate (*v*) |
| profound | bias | condition | replica |
| insert | iron | component | terminate |
| supply | proper | correctly | amplify |

#### TEXT 6

## TRIODES

1. A third element — the control grid was added between the cathode and plate of a diode and so it provided the resulting triode tube with the ability to amplify tiny signals. The control grid in this tube is a circular spiral of a number of turns of fine wire that completely surround the cathode. Because of its open construction the grid does not directly hinder the flow of electrons to the plate, but when a voltage is placed on the grid it has a profound effect on the electric field between cathode and plate and, hence, on the total electron flow.

2. Since the control grid is nearer to the cathode than the

plate, a potential placed on the grid has a much larger effect on the electric field within the tube — and hence upon the plate current — than the same potential placed on the plate. The grid thus has a controlling effect on the flow of plate current in the tube.

3. A triode requires three operating voltages, one on each electrode, to operate correctly. The plate of the tube is normally connected to a high positive voltage $E_a$ to attract the stream of electrons. A relatively low $E_{hh}$ voltage ac or dc is connected to the filament or heater to bring the cathode to its proper emitting temperature and thus make available a supply of electrons.

4. Finally, a voltage is placed on the control grid to govern the flow of plate current. This voltage generally consists of two components. One is a fixed dc voltage, called the bias $E_g$ which is normally a few volts negative with respect to the cathode. Its purpose is to operate (or bias) the tube on a definite point on its characteristic curve so that a certain amount of plate current is always flowing.

5. Superimposed upon the bias voltage is a varying or alternating voltage, usually called the signal voltage. The purpose of this voltage is to vary the flow of plate current through the tube in strict accordance with the signal variations, so as to make the plate current an amplified replica of the signal voltage. Amplification takes place, since a small variation of the signal voltage on the grid results in a large variation of the plate current through the tube. This property is used in making up amplifier's and oscillator's circuits.

1900

## EXERCISES

**I.** *Review questions:*

1. What elements does a triode consist of? 2. What structure has the control grid? 3. What effect has the grid in the tube? 4. What voltages are required to apply to the triode to operate correctly? 5. Why is the voltage placed on the grid? 6. What components does the voltage placed on the grid consist of? 7. What is the purpose of the bias voltage? 8. When does amplification take place?

**II.** *Make up an abstract of the text basing on the answers to the above questions.*

**III.** *Translate the international words without a dictionary:*

construction, structure, sum, element, component, variation, spiral, potential, circular

*IV. *Which of the following words are nouns?*[1]

| A | B | C | D |
|---|---|---|---|
| 1. employee | constructive | resistor | correctly |
| 2. general | variation | electrify | requirement |
| 3. appliance | employer | illustrate | difficult |
| 4. voltage | various | width | capable |
| 5. physician | ability | completely | weakness |
| 6. scientist | actual | freedom | organize |
| 7. difference | relative | obtained | hardship |

V. *Translate these synonyms and memorize them:*

1. place (*v*), put
2. control (*v*) govern, regulate
3. connect (*v*), join, couple
4. operate (*v*), work
5. ability (*n*), ableness, capability
6. amount (*n*), quantity
7. usually (*adv*), generally, commonly, ordinarily
8. completely (*adv*), entirely
9. proper (*adj*), suitable
10. with respect to (*adv*), with regard to

VI. *Translate these verbs and learn them:*

to require, to consist of, to vary, to result in, to provide, to amplify, to add, to operate, to call, to govern

## II.

### Pronunciation Drill 1

*Practise the sound* [eɪ]:

*nature*, great, available, say, same, arrange, change, ray, capable, gain, remain, contain, make, may, eight, made, break, evacuate, maintain, create, raise, straight

*Practise the sound* [ə:]:

certain, external, surface, thermal, further, circuit, determine, return, burn, purpose, curve, occur, turn, first, inverse, reverse

---

[1] См. Предисловие, стр. 6.

## Pronunciation Drill 2

*While reading these words pay attention to the stress markings:*

| • • | • • | • • • | • • • • |
|---|---|---|---|
| purpose | consist | neutralize | similarly |
| reason | exist | moderate | consequently |
| value | reduce | capable | accumulate |
| zero | instead | circular | positively |

### TEXT 7

## MODE OF OPERATION OF TRIODES

1. Now a voltage has been applied to the heater and the cathode is emitting a normal supply of electrons. The plate is at a high positive potential and would normally attract a large number of electrons from the space charge, if it were not for the large negative bias voltage applied to the grid from the $E_{gg}$ battery.[1]

2. Because of this large negative potential, the electrostatic field normally existing between plate and cathode cannot penetrate to the cathode and actually terminates on the grid wires. Under these conditions the grid entirely neutralizes the electrostatic field and, hence, the attraction of the plate. Since there is no electrostatic field near the cathode to draw away the electrons, the plate current through the tube is zero and a large space charge accumulates in the region between cathode and grid. The smallest negative voltage between grid and cathode that is just capable of cutting off the plate current is called the cut-off bias.[2]

3. Consider now that everything has been left unchanged, except that the negative bias voltage has been reduced to a value less than cut-off. The grid is now no longer capable of neutralizing the field between plate and cathode completely and some of the lines of force penetrate between the grid wires to the cathode. Consequently, some electrons are attracted away from the space charge and move between the grid wires towards the positive plate.

4. This results in a moderate flow of plate current. As the negative grid voltage is further reduced, that is, made less negative, progressively more electrons are able to pass between the grid wires to the plate and the plate current continues to increase.

5. When the bias voltage is removed and the grid voltage is zero, the positive voltage on the plate produces a substantial electric field at the cathode and large numbers of electrons are attracted through the grid wires to the plate, resulting in a fairly large plate current. The action is similar to that of a diode, except that the grid still has some retarding effect on the electrons because of its shielding action, and hence the plate current is somewhat less than it would be with the grid removed entirely.

6. When the bias voltage has been reversed in polarity, the grid is being made positive with respect to the cathode. The grid potential now aids the plate voltage and produces a very strong electrostatic field at the cathode, resulting in a large plate-current flow through the tube. If the grid is made sufficiently positive with respect to the cathode, a point will be reached when the electrons are attracted to the plate as fast as they can be emitted from the cathode. No space charge can accumulate under these conditions and the plate current reaches its saturation value. Still further increases in either the grid or the plate voltage cannot cause an increase in the plate current.

7. A part of the electrons is attracted to the positive grid and causes a grid current to flow between grid and cathode. Under these conditions power is dissipated in the grid circuit. To avoid this power consumption and also the large saturation plate current, which eventually can damage the tube, electron tubes are generally operated at negative grid potentials with respect to the cathode.

2800

## Commentary

1. if it were not for the large negative bias voltage applied to the grid from the $E_{gg}$ battery — если бы не большое отрицательное напряжение смещения на сетке от батареи

2. is called the cut-off bias — называется запирающим напряжением

## EXERCISES

I. *Review questions:*

1. Why is the plate current zero through the tube? 2. What is the cut-off bias? 3. When does the plate current continue to increase? 4. When does a large plate-current flow through the tube take place? 5. When does the plate current

reach its saturation value? 6. Under what conditions is power dissipated in the grid circuit? 7. Why are generally electron tubes operated at negative grid potentials with respect to the cathode?

**II.** *Make up an abstract of the text basing on the answers to the above questions.*

**III.** *Translate the international words without a dictionary:*
to produce, to neutralize, to accumulate, to reverse, to summarize, to illustrate, to stop, to operate, to select, to bombard, to convert, to class, to utilize

**IV.** *Define what parts of speech these words are and translate them:*
regulator, regulation; normal, abnormal, normally; accumulator, accumulation; mover, movement, remove, removal, movable, immovable; consequence, consequent, consequently; misuse; predetermine

**V.** *Translate these synonyms and memorize them:*
1. zero (*n*), naught, cipher, 0
2. damage (*v*), break, destroy
3. aid (*v*), help
4. present (*v*), represent
5. can (*v*), be able
6. make (*v*), produce, manufacture, do, fabricate
7. remove (*v*), draw away, take away
8. near (*adv*), close to
9. call (*v*), name, term
10. cause (*v*), give rise to

**VI.** *Translate these words and word combinations and memorize them:*
under ... conditions, further, consequently, that is, thus, somewhat, either ... or, similar, no longer, actually

## III.

### Pronunciation Drill 1

*Practise the sound* [ʌ]:

other, somewhat, thus, structure, but, number, fundamental, sum, result, some, come, become, double, conductor, impulse, couple, another, above, cover, function, govern, industrial

*Read these words with the sound* [k]:

characteristic, sketch, successful, screen, technique, **ac**company, scheme, accelerate, mechanically, acceptor, **cir**cuit, curve

## Pronunciation Drill 2

*While reading these words pay attention to the stress markings:*

| ● • | • ● | • ● • | ● • • |
|---|---|---|---|
| **s**ignal | require | convenience | summarize |
| model | apply | dimension | definite |
| axis | across | proportion | voltmeter |

### TEXT 8

## TRIODE CHARACTERISTIC CURVES

1. The relationships between the plate voltage, grid voltage and plate current in a triode, which we have explored in the last two texts, can be as in the case of the diode conveniently summarized in the triode's characteristic performance curves.[1] Actually, a three-dimensional surface model[2] is required to represent the relation between all three quantities at the same time, but for convenience two-dimensional cuts through this surface[3] will give the relation between any two quantities, while the third is held constant.

2. Thus, we can plot a curve that shows the values of the plate current $I_a$ as a function of varying plate voltages $E_a$, when the grid voltage $E_g$ is held at some fixed value. This is known as the plate current—plate voltage $(I_a - E_a)$ characteristic.[4]

3. Or we can show graphically the effect on the plate current caused by varying the grid voltage i.e. the bias, while holding the plate voltage at a constant value. This is called the plate current-grid voltage $(I_a - E_g)$ characteristic of the triode.[5]

4. We can, of course, obtain a whole set of either of these characteristics by assuming different values for the constant quantity either plate or grid voltage and plotting a curve between the remaining quantities $(I_a - E_a$, or $I_a - E_g)$ for each of these conditions. Such a set of characteristic curves is known to be a family of static triode characteristics. The term static denotes that the characteristics are obtained

when various steady voltages are applied to the tube's electrodes.

5. A circuit for obtaining the static characteristics of a triode is illustrated in Fig. 3. Variable voltage dividers or potentiometers are connected across the plate voltage and grid voltage supplies denoted by $E_{aa}$ and $E_{gg}$, respectively, to permit ascertaining the effect of varying either voltage on the tube's plate current, while the remaining voltage is held constant. The potentials at the electrodes and the plate and grid currents resulting are then measured by suitable voltmeters and amperemeters, inserted into the grid and plate circuits.

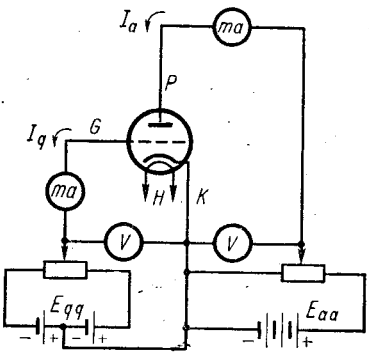


Fig. 3. Circuit for determining triode characteristics

6. A grid family of characteristic curves for a type 6J5 triode is shown in Fig. 4. In these curves the plate current $I_a$ has been plotted as a function of the grid voltage $E_g$ for various constant values of the plate voltage $E_a$. Note that each curve intersects the grid-voltage axis at a specific point that indicates the value of the negative grid voltage required to stop the plate current at the fixed value of the applied plate potential. This is the cut-off bias. As the plate voltage is increased, it may be seen that the negative bias required to cut off the plate current also increases.

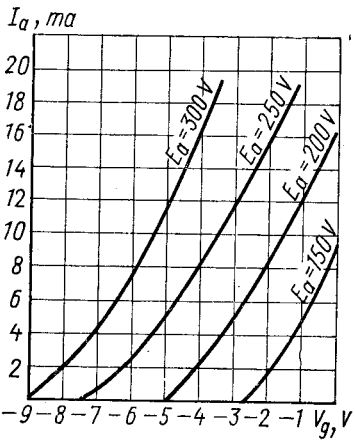


Fig. 4. Plate current-grid voltages static characteristics of 6J5

7. It is also evident that each of the graphs in Fig. 4 is quite curved in the lower portion, near cut-off, while it is almost a straight line in the central and upper portions. Triodes are almost always operated in the straight-line, linear portions of their characteristics and rarely in the

curved or non-linear portion.[6] This is so, because increases in the grid or signal voltage do not result in proportional increases of the plate current in the non-linear portion of the characteristic. But in the linear portion of the characteristic, equal changes in grid voltage cause equal changes in the plate current.

8. We can use the circuit of Fig. 3 to determine the family of static plate current-plate voltage characteristics for the 6J5 triode. The results are shown in Fig. 5. Here again, the curves have a similar shape, being curved in the lower portion near plate-current cut-off and fairly linear in the upper portions. Each curve shows the effect upon the plate current when the plate voltage is varied over a certain range, while holding the grid voltage fixed at a definite value. A new curve results each time when the grid voltage is changed to another fixed value, and when this is done over a representative range of constant grid voltages, the entire family of curves is obtained.

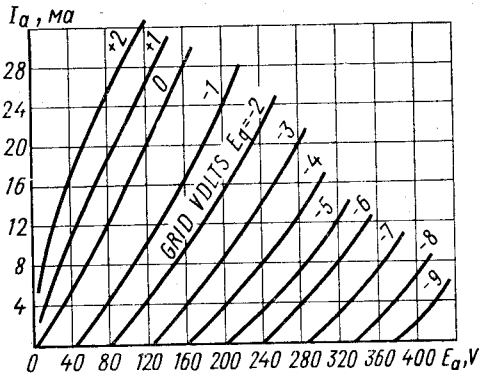


Fig. 5. Plate current-plate voltage static characteristics of 6J5 triode

9. The effect of positive grid voltages on the $I_a - E_a$ curves may be seen clearly. Even for low positive values of the grid voltage the plate current is seen to increase very rapidly with small increases in plate voltage. In addition the grid circuit of the tube draws a grid current $I_g$ for positive grid voltages. This grid current evidently decreases as the plate voltage is made large relative to the grid voltage, and the electrons are rapidly attracted to the plate.

4000

## Commentary

1. in the triode's characteristic performance curves — в семействе триодных характеристик

2. a three-dimensional surface model — трехмерная модель

3. two-dimensional cuts through this surface — двухмерное сечение этой поверхности

4. the plate current-plate voltage ($I_a - E_a$) characteristic — вольтамперная характеристика

5. the plate current-grid voltage ($I_a - E_g$) characteristic of the triode — анодно-сеточная характеристика триода

6. in the straight-line, linear portions of their characteristics and rarely in the curved or non-linear portion — на прямолинейных или линейных участках своих характеристик и редко на изогнутых или нелинейных участках

**EXERCISES**

**I.** *Review questions:*

1. What can be summarized in the triode's characteristic performance curves? 2. When are static triode characteristics obtained? 3. What does the plate current-plate voltage characteristic show? 4. What section of plate current-plate voltage characteristic is linear? 5. Why are variable voltage dividers connected across the plate voltage and grid voltage supplies? 6. What is measured by voltmeters and amperemeters while determining a family of plate current-grid voltage characteristics? 7. How are triodes almost always operated? 8. What for can the circuit in Fig. 3 be used? 9. What influence has the increase of the grid voltage on the plate current? 10. When does grid current decrease?

**II.** *Make up an abstract of the text basing on the answers to the above questions.*

**III.** *Translate these international words without a dictionary:* term, function, static, linear, proportional, graphically

***IV.** *Which of the following words are adjectives?*

| A | B | C | D |
|---|---|---|---|
| 1. equation | equal | equally | equalize |
| 2. useful | user | uselessness | usage |
| 3. valued | valuation | valuable | valueless |
| 4. variety | various | variously | variation |
| 5. operate | operator | operative | operation |
| 6. electric | electrify | electrician | electricity |
| 7. dependable | dependence | dependency | dependent |
| 8. import | importance | important | importer |

**V.** *Translate these synonyms and memorize them:*

1. denote (*v*), mean, indicate, express, show, mark
2. explore (*v*), research
3. keep (*v*), retain, hold, preserve
4. actually (*adv*), really
5. various (*adj*), different
6. intersect (*v*), cut, cross
7. ascertain (*v*), determine, define
8. shape (*n*), form
9. in addition (to) (*prep*), besides
10. rarely (*adv*), seldom, infrequently

**VI.** *Translate these words and word combinations and learn them:*

respectively, either, in addition (to), evidently, along with, rarely, even, while, slightly, fairly

## Test 1

*Find the correct answer out of the three given to each question.*

1. Which of the following tubes consists of three elements:
   a diode tube, a triode tube, a pentode tube
2. Which of the following elements was added to form a triode:
   a filament, a control grid, a plate
3. Which of the following elements has a controlling effect on the flow of plate current:
   a cathode, a plate, a grid
4. Which of the following elements is connected with a high positive voltage:
   a plate, a cathode, a grid
5. Which of the following elements is connected with a low negative voltage:
   a grid, a cathode, a plate
6. Which of the following voltages is an alternating voltage:
   a bias voltage, a signal voltage, a plate battery voltage

## Test 2

**I.** *Find Russian equivalents for the English verbs (see p. 148):*

| | |
|---|---|
| 1. consist of | (a) требовать |
| 2. vary | (b) состоять из |
| 3. govern | (c) усиливать |

| | |
|---|---|
| 4. amplify | (d) приводить к |
| 5. add | (e) работать |
| 6. provide | (f) называть |
| 7. operate | (g) обеспечивать |
| 8. call | (h) прибавлять |
| 9. require | (i) управлять |
| 10. result in | (j) изменяться |

**II.** *Find Russian equivalents for the English words and word combinations (see p. 128):*

| | |
|---|---|
| 1. under ... conditions | (a) действительно |
| 2. no longer | (b) следовательно |
| 3. similar | (c) больше не |
| 4. that is | (d) в условиях |
| 5. thus | (e) подобный |
| 6. further | (f) до некоторой степени |
| 7. somewhat | (g) или ... или |
| 8. either ... or | (h) дальше, затем |
| 9. consequently | (i) то есть |
| 10. actually | (j) таким образом |

**III.** *Find Russian equivalents for the English words and word combinations (see p. 148):*

| | |
|---|---|
| 1. in addition (to) | (a) соответственно |
| 2. even | (b) очевидно |
| 3. respectively | (c) наряду с |
| 4. along with | (d) каждый, любой |
| 5. rarely | (e) даже |
| 6. while | (f) помимо (кроме) |
| 7. fairly | (g) в то время как |
| 8. either | (h) незначительно |
| 9. slightly | (i) редко |
| 10. evidently | (j) довольно, совершенно |

**IV.** *Match these synonyms (see pp. 148):*

| | |
|---|---|
| 1. with respect to | (a) zero |
| 2. control (*v*) | (b) retain |
| 3. connect | (c) indicate |
| 4. naught | (d) usually |
| 5. keep | (e) govern |
| 6. denote | (f) name |
| 7. generally | (g) entirely |
| 8. call (*v*) | (h) give rise to |
| 9. cause (*v*) | (i) with regard to |
| 10. completely | (j) join |

## Test 3

*Find a synonym (a), (b), (c) or (d) to the word or word combination in bold type:*

1. The voltage **placed** on the grid — (a) measured; (b) changed; (c) increased; (d) put
2. The great **quantity** — (a) space; (b) area; (c) amount; (d) part
3. To **aid** the plate voltage — (a) change; (b) help; (c) vary; (d) cause
4. The **different** voltage — (a) various; (b) suitable; (c) similar; (d) same
5. A **suitable** instrument — (a) new; (b) rare; (c) proper; (d) given
6. **In addition to** this fact — (a) therefore; (b) besides; (c) instead of; (d) in spite of
7. To differ **rarely** from — (a) completely; (b) entirely; (c) slightly; (d) seldom
8. To **explore** a problem — (a) know; (b) discuss; (c) speak about; (d) research
9. To **obtain** positive charges — (a) produce; (b) attract; (c) acquire; (d) keep
10. **To give rise to** electrization — (a) use; (b) cause; (c) increase; (d) decrease
11. The electrons **can** pass through — (a) must; (b) should; (c) are able to; (d) will
12. To **present** a picture — (a) draw; (b) see; (c) discuss; (d) represent
13. The **form** of the tube — (a) size; (b) shape; (c) quality; (d) kind
14. To **damage** a device — (a) repair; (b) manufacture; (c) construct; (d) break
15. To **remove** the grid — (a) add; (b) make; (c) draw away; (d) place
16. To **manufacture** the electron tubes — (a) construct; (b) repair; (c) use; (d) produce
17. To **control** the flow of current — (a) regulate; (b) vary; (c) stop; (d) produce
18. To **ascertain** the voltage — (a) amplify; (b) determine; (c) change; (d) measure
19. To be **closer** to the grid — (a) nearer; (b) far from; (c) within; (d) away from
20. To **cut** the lines of force — (a) fix; (b) intersect; (c) represent; (d) change

## Test 4

*Finish each sentence choosing one of the three variants (a), (b) or (c) based on the texts from Section IV:*

1. A triode has...
   (a) one element; (b) two elements; (c) three elements.
2. A triode consists of...
   (a) the control grid and the plate; (b) the cathode alone; (c) the cathode, the plate and the control grid.
3. The control grid is...
   (a) between the cathode and the plate; (b) behind the plate of the diode; (c) behind the cathode of the diode.
4. A vacuum triode is...
   (a) a more simple device than a vacuum diode; (b) a more complicated device than a vacuum diode; (c) similar to a vacuum diode.
5. When a voltage is placed on the grid it has a profound effect on...
   (a) the electric field between cathode and plate; (b) the form of the plate current; (c) the form of the plate voltage.
6. The plate of the tube is normally connected to...
   (a) a low positive voltage; (b) a high positive voltage; (c) a negative voltage.
7. The heater is connected to...
   (a) a relatively low voltage; (b) the highest voltage; (c) the source of the plate voltage.
8. The plate of the tube is connected to a high positive voltage...
   (a) to repel the stream of electrons; (b) to attract the stream of electrons; (c) to cut off the stream of electrons.
9. A relatively low voltage ac or dc is connected to the heater...
   (a) to produce a supply of electrons; (b) to create a supply of positive charges; (c) to govern the flow of plate current.
10. A voltage is placed on the control grid...
    (a) to create a supply of electrons; (b) to heat a cathode; (c) to govern the flow of plate current.
11. One of the components is a fixed dc voltage, called...
    (a) the signal voltage; (b) the bias; (c) the transient voltage.

12. The purpose of the bias voltage is...
(a) to vary the flow of plate current; (b) to govern the electric field; (c) to bias the grid of the tube.
13. Superimposed upon the bias voltage is a voltage usually called...
(a) the signal voltage; (b) the bias; (c) a fixed dc voltage.
14. A small variation of the signal voltage on the grid...
(a) results in a large variation of the plate current through the tube; (b) has no influence at all on the plate current; (c) results in a small variation of the plate current through the tube.
15. The smallest negative voltage between the grid and the cathode capable of cutting off the plate current is called...
(a) the plate voltage; (b) the cut-off bias; (c) the zero grid bias.
16. The plate current is measured by...
(a) a wattmeter; (b) a voltmeter; (c) a milliamperemeter.
17. A tiny change in the grid voltage can cause...
(a) no change in the plate current; (b) the rectifying of the electric current; (c) a large change in the plate current.
18. The signal voltage appearing at the grid...
(a) is not changed; (b) is amplified in the plate circuit of the tube; (c) is rectified in the plate circuit of the tube.
19. The function relations between plate voltage, grid voltage, and plate current are called...
(a) a family of triode characteristic curves; (b) the diode characteristic curves; (c) the single characteristic curve.
20. Static characteristics are obtained...
(a) under actual operating conditions; (b) when steady dc voltages are applied to the tube's electrodes; (c) when varying voltages are applied to the tube's electrodes.

*(See keys to the tests on p. 148.)*

*Translate into Russian using a dictionary.*

## * TRIODE CONSTANTS

1. The families of triode characteristics, which show the characteristic performance of each type of tube are not a result of accident. Rather they represent the outcome of

purposeful design to make each tube behave in a certain manner. The design factors of the tube are summarized by a series of numbers, called the tube constants. The three most important constants are the amplification factor, the ac plate resistance and the transconductance.

2. The amplification factor of a triode is a measure of the relative effectiveness of the control grid in overcoming the electrostatic field produced by the plate. To determine the amplification factor it is necessary to change the plate voltage by a certain amount, record the change in plate current, and then change the grid voltage by an amount just sufficient to restore the previous plate-current value. By comparing the plate-voltage change to the grid-voltage change for the same change in plate current we can determine their relative effectiveness, which is the amplification factor.

3. We can define the amplification factor by the following symbols:

$$\text{amplification factor } \mu = -\frac{\Delta E_a}{\Delta E_g} \text{ (with } I_a \text{ constant)},$$

where $\Delta E_a$ — a small change in plate voltage
and $\Delta E_g$ — a small change in grid voltage.

4. The plate resistance describes the internal resistance of the tube to the flow of alternating plate current, when varying voltage is applied to the electrodes. The ac plate resistance is defined as the ratio of a small change in plate voltage to the change in plate current produced thereby, when the grid voltage is kept at a constant value.

5. Expressing this definition in equation forms we assume: the ac plate resistance,

$$R_l = \frac{\Delta E_a}{\Delta I_a},$$

where $\Delta I_a$ — a small change in plate current.

6. A third constant used in describing the properties of electron tubes is the control grid-to-plate transconductance designated by the symbol $S$. The transconductance is the most important of the tube constants, since it reveals the effectiveness of the control grid in securing changes in the plate current.

7. It is defined as the ratio of a small change in plate current to the small change in control-grid voltage producing it. Expressing this in equation form we assume:

$$\text{transconductance, } S = \frac{\Delta I_a}{\Delta E_g} \text{ (with } E_a \text{ constant)}.$$

8. All the three constants $\mu$, $R_i$, $S$ may be derived from the anode or anode-grid tube characteristics. If two of them are known the third one can be easily found, for the following equation will always be true:

$$\mu = R_i \cdot S.$$

The tube constants mentioned above are widely used in designing and analyzing electronic tube circuits.

*(See the Russian translation of this text on pp. 150-151)*

## SECTION FIVE

### I.

### Pronunciation Drill 1

*Practise* [s, z, ɪz] *sounds at the end of the words:*

1. [s] exists, emits, accelerates, deflects, makes, limits
   parts, groups, plates, volts, types
2. [z] gives, means, speeds, is, has, does, provides, removes, performs, extends, falls
   tubes, screens, ones, anodes, walls, fields, potentials
3. [ɪz] uses, discusses, produces, diverges, focuses, ceases
   surfaces, inches, images, places

### Pronunciation Drill 2

*While reading these words pay attention to the stress markings:*

| ● • | ● • • | • ● |
|---|---|---|
| focus | cylinder | impinge |
| final | accurate | increase (*v*) |
| increase (*n*) | several | deflect |
| hundred | multiple | effect |

#### TEXT 9

## CATHODE-RAY TUBE

1. Now let us turn to cathode-ray tubes (abbreviated CRT) that provide a visual representation of voltage and

current waveforms. Cathode-ray tubes consist of three basic components: 1. the electron gun, 2. a deflection system, 3. a fluorescent screen. These essential parts of a cathode-ray tube are mounted inside a highly evacuated, funnel-shaped glass envelope (as shown in Fig. 6) the large end of

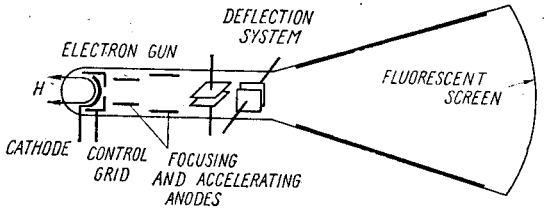


Fig. 6. Structure of electrostatic-deflection type cathode-ray tube

which has the fluorescent screen coated upon the inside surface.

2. The electron gun has the job of producing and focusing the electrons into a narrow beam so that it makes a tiny spot, when impinging on the fluorescent screen. A broad beam is of little use for accurate display of waveforms or TV pictures. An electron gun of the electrostatic type consists of an indirectly heated cathode, a control grid, an accelerating electrode or grid, a focusing anode, and a final accelerating anode. These electrodes are in the form of cylinders surrounding the cathode. Connections to the electrodes are brought to pins in the base.[1]

3. The cathode emits the electrons, the control grid determines the amount of electron flow by means of the negative bias placed on it, and the accelerating electrode being highly positive with respect to the cathode speeds up the electrons passing through it. Electrons passing through the openings in the accelerating electrode are focused into a sharp electron beam by the combined effect of the focusing anode and the final accelerating anode, which are in effect a multiple electronic lens system.[2] Both the accelerating and focusing anodes are at a positive potential with respect to the cathode but the voltage on the focusing anode is always considerably lower by several hundred to thousand volts than that on the final accelerating anode.

*(to be continued)*

1500

## Commentary

1. are brought to pins in the base — выведены на штырьки в основании лампы
2. are in effect a multiple electronic lens system — являются фактически составной системой электронных линз

## EXERCISES

**I.** *Review questions*

1. What do cathode-ray tubes provide? 2. What basic components do they consist of? 3. Where are the essential parts of the cathode-ray tube mounted? 4. What does the electron gun produce? 5. What does the electron gun consist of? 6. What does the control grid determine?

**II.** *Make up an abstract of the text basing on the answers to the above questions.*

**III.** *Translate the international words without a dictionary:*

system, form, focusing, visual, final

**IV.** *Define the meanings of the suffixes in the following words and translate the words:*

representation; directly, indirectly; combiner, combination, recombination; voltage; essentially; consideration, considerably, considerable

**V.** *Translate these synonyms and memorize them:*

1. beam (*n*), ray
2. job (*n*), work
3. accurate (*adj*), exact, precise
4. essential (*adj*), necessary, important, main, principal
5. broad (*adj*), wide
6. accelerate (*v*), speed up
7. several (*adj* & *pron*), a few, some
8. in effect, in fact
9. consist of (*v*), be made up of, be composed of
10. speed (*n*), velocity, rate of motion

**VI.** *Translate these verbs and learn them.*

to mount, to combine, to deflect, to abbreviate, to consider, to occur, to adjust, to desire, to place, to produce

## II.

### Pronunciation Drill 1

*Practise* [t, d, id] *sounds at the end of the words:*

1. [t] passed, finished, produced, developed, placed, attached, reduced, helped
2. [d] called, offered, released, ordered, mentioned, transferred, considered, supplied
3. [id] permitted, depended, heated, extended, directed, provided, consisted, coated

### Pronunciation Drill 2

*While reading these words pay attention to the stress markings:*

| • ● | ● • • | • ● • | • ● • • |
|---|---|---|---|
| bombard | otherwise | persistence | comparison |
| occur | afterglow | dependent | intensity |
| conduct | luminous | directly | material |

### TEXT 10

## CATHODE-RAY TUBE
*(Continued)*

1. If the electron beam leaving the electron gun were not deflected, it would produce a luminous spot at the centre of the fluorescent screen. The intensity of this spot can be controlled by adjusting the control-grid bias, but it is also dependent on the fluorescent material coated on the inside of the tube. Among commonly used fluorescent materials are zinc silicate, which gives off predominantly green light; zinc oxide, which gives off a blue color; zinc beryllium silicate or zinc sulphide, which glow yellow; and combination of fluorescent materials, which can be selected to give off nearly white light.

2. Another important consideration in the choice of fluorescent materials is their afterglow or persistence of glow after the electrons have ceased to bombard a spot on the screen. If the afterglow is less than 0.1 second, the screen is said to have short persistence; if it is 1 second or more, it has a long persistence. Between these limits the persistence

is medium. Short persistence is desirable for rapidly changing images, such as those displayed in television. Long persistence is occasionally of advantage, such as in radar presentations and wave-form comparisons.

3. You can readily see that some means must be provided for removing the electrons from the screen and returning them to the cathode. Otherwise the negative charge on the screen would build up to a point where it would repel arriving electrons, and no more could reach it. The method used for removing the electrons is to place a conducting coating of carbon particles, called Aquadag, along the side walls of the tube except the screen and to connect the coating to the cathode or the accelerating anode, providing a ground return to the cathode. Although the coating is not directly connected to the screen, the electrons are removed by means of secondary emission from the screen and no pile-up occurs. The secondary electrons are collected by the coating and then returned to the cathode.

4. The electron beam may be deflected either electrostatically or magnetically. Let us consider electrostatic deflection. An electrostatic field can be produced between two metal plates simply by applying a potential difference between them. Electrons entering the field between the deflecting plates will be bent in the direction of the lines of force, that is, they will be attracted toward the positive plate. The resultant path of the beam will be the net effect between its forward velocity and its deflection.[1] As a result the electron spot is deflected upward or downward depending upon the polarity of the voltage on the plate.

5. Note in Fig. 6 that two pairs of deflecting plates at right angles to each other are set into the path of the electron beam. The vertical deflecting plates move the beam vertically up and down, while the horizontal deflecting plates move the beam sideways, to the left or right of the centre.

2500

## Commentary

1. The resultant path of the beam will be the net effect between its forward velocity and its deflection. — Траектория электронного луча получится как результат взаимодействия линейной скорости электронов и отклоняющих сил.

## EXERCISES

**I.** *Review questions:*

1. By means of what can a luminous spot on the fluorescent screen be controlled? 2. What fluorescent materials are commonly used? 3. What is important consideration in the choice of fluorescent materials? 4. When is short persistence desirable? 5. What persistence is occasionally of advantage? 6. Why must some means be provided for removing the electrons from the screen and returning them to the cathode? 7. What is the Aquadag coating? 8. How may the electron beam be deflected? 9. What is the function of the vertical and horizontal deflecting plates?

**II.** *Make up an abstract of the text basing on the answers to the above questions.*

**III.** *Translate the international words without a dictionary:*

intensity, combination, polarity, silicate, sulphide, zinc, beryllium, carbon, luminous, resultant, fluorescent

***IV.** *Which of the following words are verbs?*

| A | B | C | D |
|---|---|---|---|
| 1. special | specialist | speciality | specialize |
| 2. specify | specific | specifically | specification |
| 3. long | along | length | lengthen |
| 4. alternate | alternative | alternator | alternation |

**V.** *Translate these synonyms and memorize them:*

1. means (*n*), way, manner, mode
2. method (*n*), technique
3. material (*n*), substance, matter
4. adjust (*v*), regulate
5. give off (*v*), emit
6. occur (*v*), happen, take place
7. conduct (*v*), carry, transmit, convey, guide, lead
8. select (*v*), choose
9. highly (*adv*), very
10. rapidly (*adv*), quickly

**VI.** *Translate these words and word combinations and learn them:*

readily, otherwise, by means of, let us, in effect, among, after, such as, both ... and, occasionally

## III.

### Pronunciation Drill 1

*Practise the sound* [u]:

input, output, full, push, pull, took, look, understood, should, could, would, put

*Practise the sound* [u:]:

loose, lose, too, move, remove, rule, smooth, grew, through, choose, throughout

### Pronunciation Drill 2

*While reading these words pay attention to the stress markings:*

| ● • | • ● | ● • • |
|---|---|---|
| image | retrace | increment |
| steady | thereby | synchronize |
| over | convert | interval |

### TEXT 11

## OSCILLOGRAPH

1. A cathode-ray tube is an essential part of all oscillographs and TV receivers. Consider now the way a cathode-ray tube is employed in the oscillograph. The primary purpose of the oscillograph is to convert electric signals into visual images. A simplified diagram of the oscillograph is shown in Fig. 7.

2. The oscillograph comprises, besides the cathode-ray tube, the scanning, deflection and synchronizing circuits. Like any electronic device, it is supplied with a dc voltage.

3. The voltage of the signal investigated enters the vertical deflection input of the ampli-

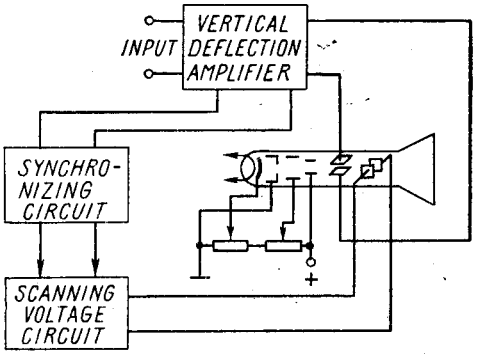


Fig. 7. Simplified diagram of the oscillograph

fier. On leaving the amplifier, the amplified signal reaches the vertical deflecting plates, creating a potential difference between them. Passing between the plates, the electron beam is deflected from its initial direction, the amount of deflection depending on the voltage of the output signal. The higher is the instant magnitude of the voltage investigated, the more is the spot deflected from the centre of the tube screen.

4. The scanning voltage supplied by the scanning circuit is fed to the horizontal deflecting plates. Under the action of this voltage, the electron beam is made to sweep along a horizontal line, moving from left to right, it is then quickly returned to the left to scan along the same horizontal line again. During this horizontal retrace period the cathode-ray tube is blocked out to make the retrace lines invisible. This retrace must be very rapid in order not to lose the information contained in the input signal.

5. Scanning is accomplished by deflecting electron beams. To do this a deflection voltage must pull the electron beam horizontally across the tube. The amplitude of this voltage must rise linearly to provide equal increments in amplitude for equal intervals of time. At the end of each scanning line the deflection voltage must fall back to zero in minimum time; that is, the retrace must be as short as possible. A waveform that provides this relatively slow linear rise in amplitude and rapid retrace to zero has the appearance of the teeth of a saw and hence, is called a saw-tooth waveform The saw-tooth scanning waveform for hizontal scanning called sweep is shown in Fig. 8.

6. When there is no input signal the electron beam traces a horizontal line on the face of the electron cathode-ray tube. When it appears, both the vertical deflecting voltage and the scanning voltage make the electron ray trace the image of the input signal on the fluorescent screen, thereby showing how the input signal voltage changes with time.

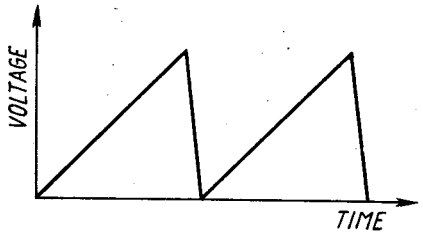


Fig. 8. Saw-tooth scanning waveform for horizontal sweep

7. To obtain a steady image on the oscillograph

screen it is necessary for each trace produced in each period of scanning to overlay most accurately the previously obtained trace. Such superposition can be obtained only, provided that each sweep coincides with the beginning of each successive period of the input signal. This is ensured by the synchronizing circuit which sends a pulse to start the scanning at the moment the input signal appears.

2000

**EXERCISES**

**I.** *Review questions:*

1. What is the primary purpose of the oscillograph? 2. What are the essential parts of the oscillograph and TV receivers? 3. What current is the oscillograph supplied with? 4. What does the amount of deflection depend upon? 5. What for is a saw-tooth waveform used? 6. How is a steady image obtained?

**II.** *Make up an abstract of the text basing on the answers to the above questions.*

**III.** *Translate the international words without a dictionary:*

pulse, period, amplitude, interval, diagram, synchronizing, information, moment, oscillograph

**IV.** *Define what parts of speech these words are and translate them:*

investigator, receiver, primary, invisible, essential, successive, initial, unnecessary, beginning, increment, retrace, superposition, reproduce, disappear, deflection, accurately

**V.** *Translate these synonyms and memorize them:*

1. image (*n*), representation
2. period (*n*), time, cycle
3. steady (*adj*), fixed, stable
4. device (*n*), gadget, instrument
5. supply (*v*), furnish, provide
6. show (*v*), indicate, illustrate, demonstrate
7. investigate (*v*), research, explore
8. accurately (*adv*), exactly
9. hence (*adv*), so, then, therefore, consequently
10. appear (*v*), become visible

**VI.** *Translate these words and word combinations and learn them:*

besides, the same, in order to, relatively, provided, thereby, such, how, along, any

## Test 1

*Find the correct answer out of the three given to each question:*

1. Which of the following tubes converts an electrical signal into a visual one:
   a diode tube, a triode tube, a cathode-ray tube
2. In which of the following devices a cathode-ray tube is used:
   a radio-receiver, an ac amplifier, an oscillograph
3. Which of the following particles are to be removed from the cathode-ray tube when it is operating:
   electrons, neutrons, gas molecules
4. By means of which of the following fields the electron deflection is produced in the above mentioned tube:
   a magnetic field, an electrostatic field, the combination of magnetic and electrostatic fields
5. Which of the following parts of the cathode-ray tube is used for producing a narrow beam of electrons:
   an electron gun, plates of the deflecting system, a fluorescent screen
6. Which of the following parts of the cathode-ray tube the investigated signal enters:
   the electron gun, the vertical deflecting plates, horizontal deflecting plates

## Test 2

**I.** *Find Russian equivalents for the English verbs (see p. 148):*

| | |
|---|---|
| 1. mount | (a) желать |
| 2. combine | (b) считать, рассматривать |
| 3. deflect | (c) случаться, появляться |
| 4. consider | (d) помещать |
| 5. adjust | (e) производить |
| 6. place | (f) объединять(ся) |
| 7. desire | (g) сокращать |
| 8. abbreviate | (h) отклонять(ся) |
| 9. produce | (i) монтировать |
| 10. occur | (j) регулировать |

**II.** *Find Russian equivalents for the English words and word combinations (see p. 148):*

| | |
|---|---|
| 1. readily | (a) иначе |
| 2. otherwise | (b) посредством |
| 3. let us | (c) среди |
| 4. in effect | (d) легко |
| 5. among | (e) после; после того как |
| 6. such as | (f) давайте |
| 7. by means of | (g) такой как; как например |
| 8. after | (h) как ... так и |
| 9. both ... and | (i) иногда, случайно |
| 10. occasionally | (j) в действительности |

**III.** *Find Russian equivalents for the English words and word combinations (see p. 148):*

| | |
|---|---|
| 1. besides | (a) тот же самый |
| 2. in order to | (b) при условии, если |
| 3. the same | (c) такой |
| 4. provided | (d) кроме того, помимо |
| 5. such | (e) любой |
| 6. how | (f) относительно |
| 7. relatively | (g) вдоль, по |
| 8. any | (h) посредством этого |
| 9. along | (i) как |
| 10. thereby | (j) для того, чтобы |

**IV.** *Match these synonyms (see pp. 148):*

| | |
|---|---|
| 1. give off | (a) in effect |
| 2. means (*n*) | (b) emit |
| 3. hence | (c) stable |
| 4. speed | (d) precise |
| 5. steady | (e) highly |
| 6. period | (f) velocity |
| 7. accurate | (g) rapidly |
| 8. in fact | (h) therefore |
| 9. quickly | (i) cycle |
| 10. very | (j) way |

## Test 3

*Find a synonym (a), (b), (c) or (d) to the word or word combination in bold type:*

1. The process **takes place** — (a) shows; (b) indicates; (c) means; (d) occurs

2. To **accelerate** electrons — (a) conduct; (b) focus; (c) emit; (d) speed up

3. To **regulate** a device — (a) produce; (b) fix; (c) adjust; (d) construct

4. To **choose** a conductor — (a) apply; (b) use; (c) connect; (d) select

5. A **broad** beam — (a) long; (b) wide; (c) light; (d) short

6. An electron **beam** — (a) flow; (b) ray; (c) gun; (d) device

7. To **indicate** the polarity — (a) represent; (b) show; (c) use; (d) provide

8. To **guide** electrons — (a) liberate; (b) conduct; (c) give off; (d) accelerate

9. A difficult **job** — (a) task; (b) work; (c) situation; (d) position

10. The applied **technique** — (a) machine; (b) instrument; (c) method; (d) device

11. To **consist of** elementary particles — (a) knock out; (b) depend on; (c) find; (d) be made up of

12. To **investigate** the voltage — (a) research; (b) determine; (c) know; (d) measure

13. A **highly** sensitive device — (a) good; (b) new; (c) very; (d) modern

14. **Several** devices — (a) a lot of; (b) the same; (c) five; (d) a few

15. The battery **supplies** energy — (a) uses; (b) changes; (c) furnishes; (d) adjusts

16. To move **rapidly** — (a) in the same way; (b) quickly; (c) slowly; (d) quietly

17. **Accurately** obtained trace — (a) usually; (b) earlier; (c) exactly; (d) previously

18. The **image** of the input signal — (a) form; (b) speed; (c) period; (d) representation

19. The **essential** part of — (a) main; (b) other; (c) second; (d) last

20. The same kind of **matter** — (a) work; (b) substance; (c) energy; (d) voltage

## Test 4

*Finish each sentence choosing one of the three variants (a), (b) or (c) based on the texts from Section V:*

1. Cathode-ray tubes provide...

(a) the generating of the sound waves; (b) amplification of low electrical signal; (c) a visual representation of voltage and current waveforms.

2. Cathode-ray tubes consist of...
   (a) one basic component; (b) two basic components; (c) three basic components.
3. One of the essential parts of a cathode-ray tube is...
   (a) an electron gun; (b) a source of positive voltage; (c) a transistor amplifier.
4. A narrow beam produced by an electron gun accelerates focuses and consists of...
   (a) positive ions; (b) electrons; (c) protons.
5. A deflection system...
   (a) produces electrons; (b) deflects the electron beam; (c) is the source of electrons.
6. A fluorescent screen produces...
   (a) an electron beam; (b) an alternating current; (c) a spot of visible light.
7. The fluorescent screen is covered with...
   (a) fluorescent materials; (b) conducting coating of carbon particles; (c) a thin copper coating.
8. The essential parts of a cathode-ray tube are housed in...
   (a) a hollow cylinder; (b) a glass envelope; (c) a metal box.
9. The method used for removing the electrons from the screen and returning them to the cathode is...
   (a) to place the Aquadag coating; (b) to remove the cathode; (c) to place an anode battery.
10. The essential part of all oscillograph and TV receivers is...
    (a) a transistor oscillator; (b) a cathode-ray tube; (c) a generator of the alternating current.
11. The primary purpose of the oscillograph is to convert...
    (a) electric signals into visual images; (b) an alternating current into a direct current; (c) a saw-tooth waveform into a sinewave.
12. The oscillograph comprises, besides the cathode-ray tube...
    (a) a sinewave voltage oscillator; (b) the scanning, deflection and synchronizing circuits; (c) a tube tank circuit.
13. The electron gun of the cathode-ray tube of the oscillograph is supplied with...
    (a) dc voltage; (b) ac voltage; (c) a dumping sinewave.

14. The voltage of the signal investigated enters...
(a) the horizontal deflection input of the amplifier; (b) the vertical deflection input of the amplifier; (c) the filament circuit of the cathode-ray tube.
15. The amount of vertical deflection depends on...
(a) the strength of the current of the cathode-ray tube; (b) the input signal of the horizontal amplifier; (c) the voltage of the output signal of the vertical amplifier.
16. Scanning is accomplished by...
(a) deflecting electron beams along the horizontal line; (b) changing the filament voltage of the cathode-ray tube; (c) changing the amount of electrons getting on the fluorescent screen.
17. A waveform that provides the relatively slow linear rise in amplitude and rapid retrace to zero has the appearance of...
(a) the straight line; (b) the sinewave; (c) the teeth of a saw.
18. A waveform that has the appearance of the teeth of a saw is called...
(a) a saw-tooth waveform; (b) a dc voltage waveform; (c) a sinewave.
19. To obtain a steady image on the oscillograph screen it is necessary...
(a) to change sharply the filament voltage in accordance with the input signal; (b) to overlay most accurately the previously obtained trace; (c) to reduce the light spot on the screen of the oscillograph.
20. Superposition can be obtained only, provided...
(a) the input signal is slowly changed; (b) the saw-tooth voltage is absent; (c) each sweep coincides with the beginning of each successive period of the input signal.

*(See keys to the tests on p. 148)*

*Translate into Russian without a dictionary.*

TEXT

1. Cathode-ray tubes convert an electrical signal into a visual one by shooting a beam of electrons at a fluorescent screen and deflecting the beam in accordance with the va-

riations of the electrical signal. Cathode-ray tubes consist of an electron-gun, a deflection system, and a fluorescent screen, all housed in a glass envelope.

2. The electron gun — usually made up of a heater-type cathode, a control grid, an accelerating electrode or grid, a focusing anode, and a final accelerating anode — produces, accelerates and focuses the emitted electrons into a narrow beam. It acts as an electron emitter and electronic lens system.

3. The fluorescent screen is coated with a phosphor zinc silicate, zinc oxide, zinc sulphide that produces visible light when electrons impinge on it.

4. The oscillograph comprises the cathode-ray tube, the scanning, deflection and synchronizing circuits. It is supplied with a direct current. The oscillograph converts electric signals into visual images. To obtain a steady image on the oscillograph screen it is necessary for each trace produced in each period of scanning to overlay most accurately the previously obtained trace.

1000

## SECTION SIX

### I.

### Pronunciation Drill 1

*Practise the sound* [ʃ]:

initial, commercial, appreciable, associate, potential, substantial, sharp, pressure, ratio, shade, especially, shape, share

### Pronunciation Drill 2

*While reading these words pay attention to the stress markings:*

| ● • | • ● | • ● • | ● • • |
|---|---|---|---|
| recent | respect | discussion | popular |
| solid | assume | adjacent | silicon |
| crystal | dislodge | conduction | diamond |
| valence | prevail | transistor | terminal |

## TEXT 12

# TRANSISTORS AND SEMICONDUCTORS

1. In recent years the transistor — an entirely new type of electron device — has come into its own[1] and bids to replace the bulky electron tubes in many applications. Transistors are far smaller than tubes, have no filament and hence need no heating power. They are mechanically rugged, have practically unlimited life, and can do some jobs better than electron tubes, while catching up fast in other respects.[2]

2. In contrast to electron tubes, which utilize the flow of free electrons through a vacuum or gas, the transistor relies for its operation on the movement of charge carriers through a solid substance, a semiconductor. Transistors are only one of the family of semiconductors; many other semiconductor applications are becoming increasingly popular and new ones are constantly being discovered.

3. It is known that materials are classed as semiconductors if their electrical conductivity is intermediate between metallic conductors, which have a large number of free electrons available as charge carriers, and non-metallic insulators, which have practically no free electrons available to conduct current. The two semiconductors most frequently used in electronics and transistor manufacture are germanium and silicon. Both elements have the same crystal structure and similar characteristics, so that the discussion that follows for germanium will also apply to silicon.

4. It is known that outermost electron shell of an atom contains the loosely held valence electrons, which are easily dislodged to become electric current carriers. Germanium has four valence electrons in its outer shell, and for our purposes, the atom may be pictured as containing only these electrons and four protons in the nucleus to keep it electrically neutral.

5. When germanium is in crystalline form its atoms assume the typical diamond structure. In this structure adjacent germanium atoms share their valence electrons in a strong bond, so that effectively four orbital electron pairs are associated with each nucleus. These electron pairs are termed covalent bonds and they are bound so strongly to each other and to the nucleus that no free electrons are available to conduct a current through the germanium.

6. A pure germanium crystal, therefore, is practically a non-conductor of electricity. It is not completely non-

conducting, since ordinary heat energy occasionally disrupts some of the covalent bonds, thus liberating free electrons as charge carriers.

7. If a small amount of an impurity is introduced into the germanium crystal, its current-conducting characteristics change radically. Thus, when atoms that have five electrons in their outer shell are introduced into the germanium, a procedure known as doping, the fifth electron of the impurity atom does not find a place in the symmetrical covalent-bond structure and, hence, is free to roam around through the crystal. These free electrons are then available as electric current carriers.

8. By placing an electric field across the "doped" germanium crystal, the excess of free electrons donated by the impurity atoms will travel toward the positive terminal of the voltage source. Relatively few impurity or "donor" atoms within the germanium structure permit fairly substantial electron currents through the crystal when an electric field is applied. Germanium that has been doped by pentavalent donor atoms is known to be *n*-type germanium, because current conduction is carried on with negative charge carriers, or electrons.

9. Consider now the situation when an impurity that has only three electrons in its outer shell is introduced into the pure germanium crystal. The trivalent indium atoms take their place in the germanium structure, but one of the covalent bonds around each indium atom has an electron missing,[3] or a hole in its place. Although the hole indicates the absence of an electron it behaves like a real, positively charged particle when an electric field is applied across the crystal.

10. Under the influence of the electric field, electrons within the crystal will tend to move toward the positive terminal of the voltage source and jump into the available holes of the indium atoms near the positive terminal. Since there are no free electrons available, the deficient indium atoms near the positive terminal "steal" electrons from their neighbors by disrupting their covalent bonds. This creates new holes in adjacent atoms.

11. As electrons move toward the positive terminal, the holes will move toward the negative terminal, thus acting like mobile, positive particles. As the holes reach the negative terminal, electrons enter the crystal near the terminal and combine with the holes, thus cancelling them.

12. At the same time, the loosely held electrons that filled the holes near the positive terminal, are attracted away from their atoms into the positive terminal. This, of course, creates new holes near the positive terminal, which again drift toward the negative terminal. Current conduction may thus be considered to occur by means of holes inside the crystal, and by means of electrons through the external connecting wires and battery.

13. An impurity that has three electrons in its outer shell is known as an acceptor atom, because it takes electrons away from surrounding germanium atoms. Germanium that has been doped with trivalent acceptor atoms is called *p*-type germanium, to specify that current conduction is carried on by holes, which are the equivalent of positive charges.

4700

## Commentary

1. has come into its own — стал совершенно самостоятельным
2. while catching up fast in other respects — и широко применяется в других областях техники
3. an electron missing — недостающий электрон

## EXERCISES

**I.** *Review questions:*

1. What is a transistor? 2. What do transistors replace? 3. What are two most frequently used varieties of semiconductors? 4. What structure do germanium and silicon have? 5. Why is a pure germanium crystal practically called a non-conductor? 6. When do the current-conducting characteristics of the germanium crystal change? 7. What procedure is known as doping? 8. What is *n*-type germanium? 9. What is an acceptor atom? 10. What is *p*-type germanium?

**II.** *Make up an abstract of the text basing on the answers to the above questions.*

**III.** *Translate the international words without a dictionary:*

situation, procedure, variety, popular, neutral, crystalline, mobile, equivalent, trivalent, real, practically, radically

**IV.** *Explain what meanings prefixes and suffixes give to the following words and translate the words:*

remainder, collector, carrier, amplifier, detector, semiconductor, emitter, rectifier, unfavourable, independent, impurity, non-metallic, recombination, mover, movement, movable, specify, loosely

**V.** *Translate these synonyms and memorize them:*

1. free (*adj*), loose
2. often (*adv*), frequently
3. substantial (*adj*), essential
4. instant (*n*), moment
5. pair (*n*), couple, two
6. disrupt (*v*), break
7. procedure (*n*), process
8. create (*v*), build up
9. radically (*adv*), completely, entirely
10. variety (*n*), kind, change, difference

**VI.** *Translate these verbs and learn them:*

to replace, to rely, to introduce, to travel, to enter, to behave, to cancel, to associate, to liberate, to permit

## II.

### Pronunciation Drill 1

*Practise the sound* [dʒ]:

germanium, generate, energy, exaggerate, just, region, junction, gadget, logical, inject, majority, ingenious, advantage, charge, voltage, stage, giant, geometry, procedure, range, adjacent

### Pronunciation Drill 2

*While reading these words pay attention to the stress markings:*

| •● | ●•• | •●•• |
|---|---|---|
| below | generate | impurity |
| before | liberate | vicinity |
| arrive | indicate | effectively |
| abrupt | equally | extensively |

### TEXT 13

## P—N JUNCTION DIODES

1. Conduction of electric current through *p*- or *n*-type germanium takes place equally well in either direction;

hence, reversing the polarity of the battery will not affect the amount of current flow, although it reverses its direction.

2. Consider now what happens when *p*-type germanium is joined to *n*-type germanium and a voltage is applied across the junction. With the *p*-type germanium biased positively, as illustrated in Fig. 9a, the holes are repelled by the

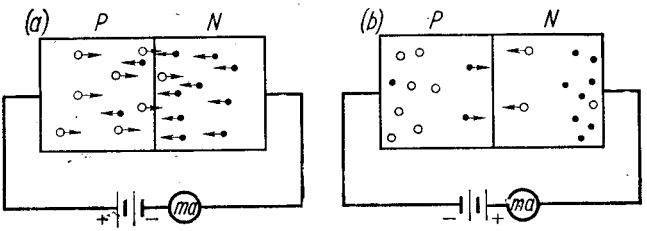


Fig. 9a, b. Current flows across *p—n* junction with forward and reverse bias

battery voltage toward the junction between the *p*- and *n*-type material. Simultaneously, the electrons in the *n*-type germanium are repelled by the negative battery voltage toward the *p—n* junction.

3. Although there is normally a potential barrier at the *p—n* junction that prevents electrons and holes from moving across and combining, under the influence of the electric field of the battery the holes move to the right across junction and the electrons move to the left. In the region of the *p—n* junction, therefore, electrons and holes meet and combine, thus ceasing to exist as mobile charge carriers.

4. For each electron hole combination that takes place near the junction, a covalent bond near the positive battery terminal breaks down, an electron is liberated and enters the positive terminal. This action creates a new hole which moves to the right toward the *p—n* junction.

5. At the opposite end, in the *n*-region near the negative terminal, more electrons arrive from the negative battery terminal and enter the *n*-region to replace the electrons lost by combination with holes near the junction. These electrons move toward the junction at the left, where they again combine with new holes arriving there. As a consequence, a relatively large current flows through the junction. The current through the external connecting wires and bat-

tery is carried by positive charges, in the direction shown in Fig. 9a.

6. The battery connection that permits current to flow across the $p$—$n$ junction is known as forward bias. A minimum voltage of about 0.1 volt is needed to overcome the potential barrier at the junction and permit any current to flow as shown in Fig. 10. The current then increases rapidly with increasing battery voltage.

7. If the battery voltage is reversed in polarity, as illustrated in Fig. 9b, an entirely different situation prevails. The holes are now attracted to the negative battery terminal and move away from the $p$—$n$ junction, while the electrons also move away from the junction because of the attraction of the positive terminal.

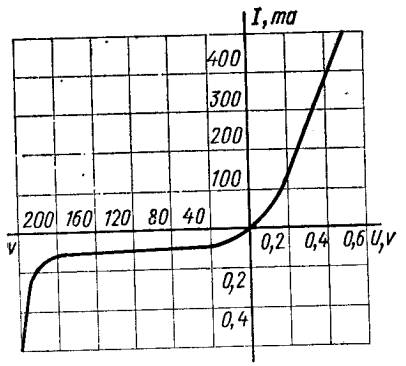


Fig. 10. Volt-ampere characteristic curve of a $p$—$n$ junction

8. Since there are effectively no hole and electron carriers in the vicinity of the junction, current flow stops almost completely. A small reverse current of a few microamperes still flows across the junction. This reverse current is due to thermally generated electron-hole, within both the $p$- and $n$-type materials.

9. As mentioned before, some covalent bonds always break down because of the normal heat energy of the crystal molecules. Electrons liberated by this process in the $p$-material move right across the junction under the influence of the electric field, while holes generated in the $n$-material move to the left into the $p$-material. Thus a small electron-hole combination current[1] is maintained by these so-called minority carriers.

10. If the reverse bias is made very high, the covalent bonds near the junction break down, and a large number of electron-hole pairs will be liberated; the reverse current then increases abruptly to a relatively large value and $p$—$n$ junction breaks down.

11. The unilateral current conduction characteristic of a $p$—$n$ junction is seen to be similar to that of the conventional diode tube. Germanium and other semiconductor diodes are extensively used as rectifiers and detectors.

2300

## Commentary

1. a small electron-hole combination current — небольшой электронно-дырочный ток

### EXERCISES

**I.** *Review questions:*

1. In what direction does conduction of electric current through $p$- or $n$-type germanium take place? 2. What happens when $p$-type germanium is biased positively? 3. What is forward bias? 4. How does the battery voltage influence the direct current? 5. When do the covalent bonds near the junction break down? 6. What devices are extensively used as rectifiers and detectors?

**II.** *Make up an abstract of the text basing on the answers to the above questions.*

**III.** *Translate the international words without a dictionary:* to combine, to prevail, to repeat, to diffuse, to generate, to inject

***IV.** *Which of these words have negative prefixes?*

| | A | B | C | D |
|---|---|---|---|---|
| 1. | overwork | non-relative | semiconductor | reopen |
| 2. | impossible | underestimate | illegal | misuse |
| 3. | co-exist | unanswerable | sub-group | dissymmetrical |
| 4. | forecast | self-service | irresistible | prehistoric |
| 5. | mislead | interaction | invisible | superexcellent |

**V.** *Translate these synonyms and memorize them:*

1. meet (*v*), encounter
2. every (*adj*), each
3. maintain (*v*), support, keep
4. prevail (*v*), predominate
5. stop (*v*), cease
6. increase (*v*), enlarge, raise
7. affect (*v*), influence
8. liberate (*v*), release, free

9. vicinity (*n*), region
10. extensively (*adv*), widely, broadly

**VI.** *Translate these words and word combinations and learn them:*

simultaneously, almost, in contrast, practically, frequently, of course, abruptly, as a consequence, before, entirely

## III.

### Pronunciation Drill 1

*Practise the sound* [s]:

since, centre, valence, circuit, vicinity, cancel, accelerate, specific, procedure, practice, cease, consequence

*Practise the sound* [ʒ]:

measure, diffusion, conclusion, visual, precision, decision

### Pronunciation Drill 2

*While reading these words pay attention to the stress markings:*

| ● • | • ● | • ● • | ● • • |
|---|---|---|---|
| region | repeat | extremely | evident |
| mobile | reverse | displacement | ruggedness |
| central | combine | extension | vacuum |

### TEXT 14

## TRANSISTORS

1. Just as the triode tube followed on the heels of[1] the vacuum diode, you might expect that the logical extension of the semiconductor diode junction would be a triode junction, consisting of two *p—n* junctions. This is indeed the case, and the modern *p—n—p* or *n—p—n* junction triode transistors are in many respects analogous to triode electron tubes. A junction transistor has advantages of long life, small size, ruggedness and absence of cathode heating power.[2]

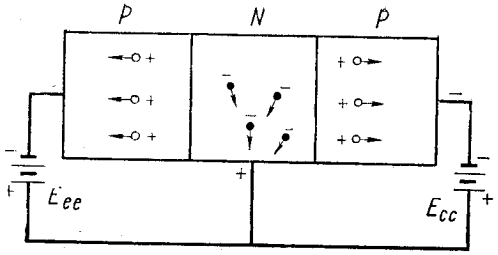


Fig. 11. Non-conducting $p-n-p$ junction transistor

2. Fig. 11 illustrates a $p—n—p$ junction, made up of a sandwich of two $p—n$ germanium junction diodes, placed back to back.[3] Although exaggerated in the illustration, the centre or $n$-type portion of the sandwich is extremely thin in comparison to the $p$-regions.

3. With the battery polarities as shown in Fig. 11, the $p$-regions are negative with respect to the central $n$-region or conversely the $n$-region called the base is positive with respect to the $p$-regions. The mobile electrons in the $n$-region, therefore, initially move away from both junctions in the direction of the positive connecting terminal. The holes in each of the $p$-regions also move away from the junctions and are attracted toward the negative terminals. After these initial displacements of holes and electrons the current flow stops.

4. Consider now the same $p—n—p$ sandwich, but with the batteries connected as in Fig. 12. Note that the $p$-region at the left of Fig. 12 is biased positively, in the forward direction, while the $p$-region at the right is biased negatively in the reverse direction.

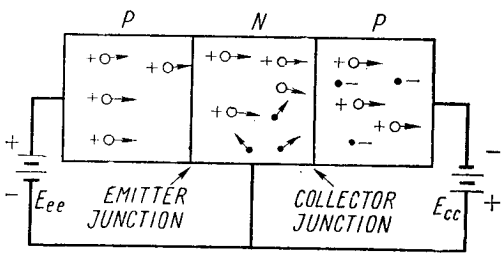


Fig. 12. Basis connection of $p-n-p$ junction transistor

5. The holes in the left $p$-region, known as emitter are repelled by the positive battery terminal toward the left $p—n$ emitter junction. Under the influence of the electric field the holes overcome the barrier and cross the emitter

junction into the *n*-type or base region. This region is very thin and only lightly "doped" with impurity atoms, so that the majority of the holes are able to drift across the base without meeting electrons to combine with.

6. A small number of holes, however, are lost in this area because of recombination with electrons. The remainder penetrates through the almost porous base regions and flows across the right junction into the *p*-region or collector. The junction with a reverse bias in a transistor is termed collector junction. The negative collector voltage $E_{cc}$ aids in rapidly sweeping up the holes that pass into the collector region.

7. As each hole reaches the collector electrodes, an electron is emitted from the negative battery terminal $E_{cc}$ and neutralizes the hole. For each hole that is lost by combination with an electron in the collector and base areas, a covalent bond near the emitter electrode breaks down and a liberated electron leaves the emitter electrode and enters the positive battery terminal $E_{cc}$. The new hole that is formed then moves immediately forward the emitter junction, and the process is repeated.

8. Current conduction within the *p-n-p* transistor thus takes place by hole conduction from emitter to collector while conduction in the external circuit is carried on by electrons. Furthermore, the collector current must be less than the emitter current by an amount proportional to the number of electron-hole combinations occurring in the base area.

9. The ratio of collector current to emitter current is known as alpha and it is a measure of the possible current amplification in a transistor. From the definition, alpha cannot be higher than 1, but practical values of 0.95 to 0.99 are attained in commercial transistors.

10. Because of the reverse bias no current can flow in the collector circuit, unless current is introduced into the emitter. Since a small emitter voltage of about 0.1 to 0.5 volt permits the flow of an appreciable emitter current, the input power to the emitter circuit is quite small. As we have seen, the collector current due to the diffusion of holes is almost as large as the emitter current. Moreover, the collector voltage $E_{cc}$ can be as high as tens of volts, thus permitting relatively large output powers.

11. A large amount of power in the collector circuit may thus be controlled by a small amount of power in the emit-

ter circuit. The power gain in a transistor thus may be quite high, reaching values in the order of 1000. The *n-p-n* transistor is similar to the *p-n-p* transistor except that the polarities are reversed. Thus the negatively biased *n*-type emitter injects electrons which diffuse through the narrow *p*-region and are collected by the positively biased collector.

3600

## Commentary

1. on the heels of — по пятам, следом за
2. of cathode heating power — мощности для подогрева катода
3. made up of a sandwich of two *p—n* germanium junction diodes, placed back to back — сделанный из двух германиевых переходов, расположенных слоями, навстречу друг другу

## EXERCISES

**I.** *Review questions:*

1. What are transistors analogous to? 2. What advantages does a junction transistor have? 3. What potentials must the emitter and the collector have to permit the current flow through the transistor? 4. What is emitter junction? 5. What is collector junction? 6. What properties must the base of the transistor possess?

**II.** *Make up an abstract of the text basing on the answers to the above questions.*

**III.** *Translate the international words without a dictionary:*

base, collector, definition, proportion, modern, analogous, porous, commercial

**IV.** *Define to what parts of speech these words belong and translate them:*

proportion, proportional, proportionally; illustration, illustrative, illustrating, illustrated; conclusion, conclusive; polarity, polarization; interchange, interchangeable, interchangeably

**V.** *Translate these synonyms and memorize them:*

1. modern (*adj*), up-to-date, latest, new
2. gather (*v*), collect
3. enter (*v*), come in
4. associate (*v*), connect, join

5. therefore (*adv*), hence, consequently
6. evident (*adj*), clear, obvious, apparent
7. case (*n*), example, instance
8. moreover (*adv*), furthermore
9. immediately (*adv*), at once
10. due to (*adv*), thanks to

**VI.** *Translate these words and word combinations and learn them:*

in comparison to, immediately, furthermore, just as, indeed, in many respects, unless, initially, due to, conversely

## IV.

### Pronunciation Drill 1

*Practise the sound* [e]:

enter, inject, however, process, direction, electron, repel, present, instead, readily, heavy, evidence, meant, measure

*Practise the sound* [æ]:

arrow, polarity, transistor, battery, barrier, latter, carrier, rapid, analysis, analyze, alpha, manufacture, ampere, classify

### Pronunciation Drill 2

*While reading these words, pay attention to the stress markings:*

| ● • | • ● | • ● • | ● • • |
|---|---|---|---|
| somewhat | suffice | resemble | ratio |
| input | entire | potential | illustrate |
| output | impress | relation | minimum |
| also | produce | resistance | opposite |

### TEXT 15

## TRANSISTOR CHARACTERISTIC CURVES

1. The performance of transistors may be determined from characteristic curves of their voltage and current rela-

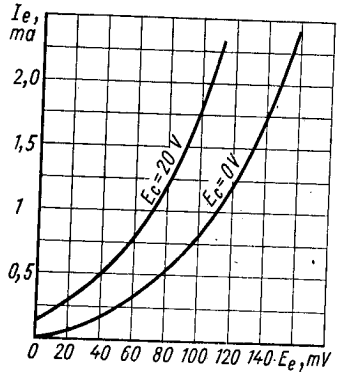


Fig. 13. Emitter current vs emitter-to-base voltage for a $p-n-p$ junction transistor

tions, just as for conventional electron tubes. Fig. 13 illustrates the variation of the emitter current as a function of the emitter-to-base voltage[1] $E_e$ for a $p$-$n$-$p$ junction triode transistor.

2. The emitter current increases rapidly with small increments in the emitter voltage. Moreover, the emitter current is almost independent of the collector-to-base voltage[2] $E_c$, although there is a small interaction, as shown by the two curves for $E_c=0$ and $E_c=10$ volts.

3. The main point to note is that a very small emitter voltage suffices to produce a large flow of emitter current. This also means that a small signal voltage variation at the input of the transistor produces a large emitter current variation, or equivalently, the input resistance to a small signal voltage impressed on the emitter is very low.[3]

4. A family of collector current — collector voltage $I_c$—$E_c$ characteristics[4] for the same $p$—$n$—$p$ junction transistor is shown in Fig. 14. Each curve in Fig. 14 represents the variation in collector current with changing collector-base voltage $E_c$ for a constant value of the emitter current $I_e$. Note that almost the entire variation in the collector current takes place at very low value of the collector voltage.

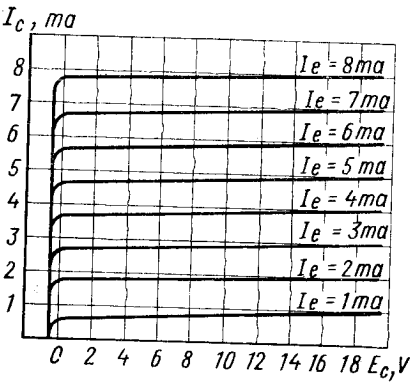


Fig. 14. Collector current vs collector-to-base voltage for a $p-n-p$ junction transistor

5. When the collector voltage is raised above a value of about one to two volts, it collects all the charge carriers that diffuse via the base to the collector junction, and the

collector current becomes practically independent of the collector voltage. The collector current above this minimum potential is nearly, but not quite, equal to the emitter current for each curve. You will remember that the collector current cannot equal the emitter current because of the small percentage of charge carriers lost in the base due to electron-hole combinations.

6. The $I_c - E_c$ curves in Fig. 14 also show that a very large change in the collector voltage produces only a tiny change in the collector current, which means that the output resistance of the transistor i.e. the ratio of the voltage-to-current change[5] is also very high. This sheds some light on the process of voltage and power amplification in a transistor.

7. We have already determined that a small signal voltage impressed in the low-resistance emitter circuit of a transistor produces a relatively large emitter current. Almost the same amount of current will flow in the high-resistance collector circuit of the transistor, where the voltage may be very high. Evidently, then, both the output voltage and output power can be quite large, compared to the tiny input voltage and power present at the emitter.

2300

## Commentary

1. As a function of the emitter-to-base voltage — как функции напряжения эмиттер — база

2. of the collector-to-base voltage — напряжения коллектор — база

3. the input resistance to a small signal voltage impressed on the emitter is very low — входное сопротивление для сигналов низкого напряжения, подаваемых к эмиттеру, очень мало

4. A family of collector current — collector voltage $I_c - E_c$ characteristics — семейство характеристик коллекторный ток — коллекторное напряжение

5. i.e. the ratio of the voltage-to-current change — т.е. отношение изменения напряжения к изменению тока

## EXERCISES

I. *Review questions:*

1. What determines the performance of transistors? 2. How does the emitter current increase? 3. How does the emitter current depend on the collector-to-base voltage? 4. What voltage suffices to produce a large flow of emitter

current? 5. Why cannot the collector current equal the emitter current? 6. When does the collector voltage collect all the charge carriers?

**II.** *Make up an abstract of the text basing on the answers to the above questions.*

**III.** *Define the meanings of the suffixes and prefixes in the following words and translate the words:*

actor, action, interaction, active, activity, actively; dependent, independent, dependable, dependence, independence, dependency; formation, formative, former, formless, formula, formulate, formulation; relative, relatively, relation

**IV.** *Translate these synonyms and memorize them:*

1. because of (*prep*), on account of
2. above (*adv*), higher, over, more, greater than, more than
3. diffuse (*v*), dissipate
4. rapid (*adj*), fast
5. via (*adv*), through
6. equal (*adj*), equivalent, adequate, same
7. conventional (*adj*), usual, common
8. remember (*v*), keep in mind
9. although (*conj*), though
10. note (*v*), mention

**V.** *Brush up these words and word combinations:*

then, than, although, through, nearly, necessarily, evidently, moreover, due to, relatively

## V.

### Pronunciation Drill 1

*Practise the sound* [ɑ:]:

charge, large, pass, ask, fast, last, regardless, advantage, part, partial, example, branch, past, task, after, afterwards

### Pronunciation Drill 2

*While reading these words pay attention to the stress markings:*

| • ● | ● • | • ● • | • ● • • |
|---|---|---|---|
| compact | symbol | distinguish | analogous |
| provide | forward | assumption | identical |
| despite | inward | accordance | conventional |
| perform | into | efficient | necessitate |

## TRANSISTOR SYMBOLS AND CONNECTIONS

1. You've met *p-n-p* and *n-p-n* transistors and found out something about their operation. But in order to recognize a transistor when you see one in a circuit you must become familiar with some of the forms, connections, and circuit symbols used to schematize them. Fig. 15 illustrates

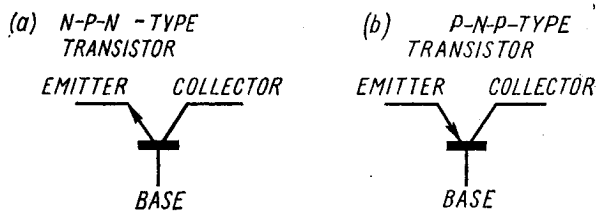


Fig. 15. Transistor circuit symbols *n-p-n*-type and *p-n-p*-type

the circuit symbols used for *n-p-n* transistors (a) and *p-n-p* transistors (b). Note that in each case the emitter is distinguished from the collector by an arrow, which indicates the direction of conventional current flow with forward bias. The conventional current flow is opposite in direction to electron flow.

2. When transistors are operated as an amplifier, three different basic circuit connections are possible, as illustrated in Fig. 16. These are (A) common-base,[1] (B) common-emitter,[2] and (C) common-collector.[3] Each of these circuit configurations has specific advantages and limitations.

3. Note that regardless of the circuit connection the emitter is always biased in a forward direction, while the collector always has a reverse bias, in accordance with the basic connections shown in Fig. 12. This necessitates a positive emitter bias and a negative collector bias for the *p-n-p* transistor, while opposite polarities are required for the *n-p-n* transistor. Except for this polarity reversal, the connections for *p-n-p* and *n-p-n* transistors are identical.

4. The common-base connection is shown in Fig. 16 (A). We have already become familiar with the common-base connection, since it is convenient for illustrating transistor physics. As we found out, this circuit provides a very low input resistance, and a high output resistance. The common-

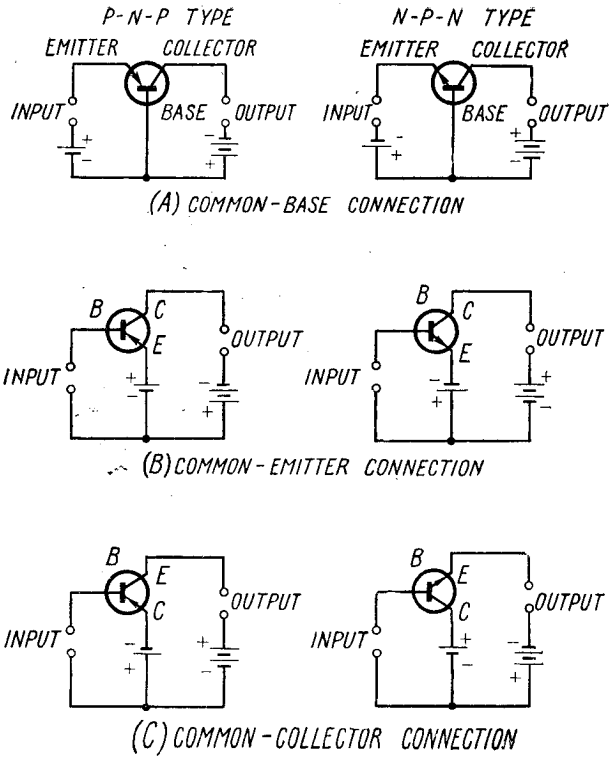


Fig. 16. Transistor amplifier circuit connections

base circuit provides respectable voltage and power amplification, as was mentioned earlier.

5. The common-emitter circuit in Fig. 16 (B) is the most flexible and efficient of the three basic connections. While its input resistance is somewhat higher and its output resistance is lower than that of the common-base connection, the common-emitter connection has the highest voltage and power gain of the three circuits. Like the equivalent vacuum-tube circuit, the common-emitter connection produces a phase reversal between the input and output signals. No such phase reversal occurs with the other two connections.

6. The common-collector connection in Fig. 16 (C) provides a relatively high input resistance, a low output resistance, and about the same current gain as the common-emitter circuit. Its voltage gain, however, is always less

than one. The common-collector circuit is primarily used for impedance matching and as a buffer stage.[4]

1700

### Commentary

1. (A) common-base — схема с общей базой
2. (B) common-emitter — схема с общим эмиттером
3. (C) common-collector — схема с общим коллектором
4. for impedance matching and as a buffer stage — для согласования сопротивлений и как буферный каскад

### EXERCISES

**I.** *Review questions:*

1. What are three basic circuit connections? 2. What connection is the most flexible and efficient? 3. What does the common-emitter connection produce? 4. What is the common-collector circuit primarily used for? 5. What properties does common-base connection possess?

**II.** *Make up an abstract of the text basing on the answers to the above questions.*

**III.** *Translate the international words without a dictionary:*

physics, symbol, phase, configuration, identical, specific.

**IV.** *Define what parts of speech these words are and translate them:*

necessitate, necessity, necessarily, unnecessary, necessitous; inward, upward, downward, towards, forward; amplifier, amplification

**V.** *Translate these synonyms and memorize them:*

1. device (*n*), instrument, appliance
2. mainly (*adv*), primarily, chiefly
3. find out (*v*), learn
4. specific (*adj*), special
5. necessitate (*v*), require
6. provide (*v*), furnish
7. in order to (*prep*), so that, in order that
8. earlier (*adv*), previously, before
9. identical (*adj*), the same
10. in accordance with (*prep*), according to

**VI.** *Brush up these words and word combinations:*

in order to, except for, regardless, primarily, as in the case, such, like, as mentioned earlier, somewhat, already

## Test 1

*Find the correct answer out of the three given to each question:*

1. Which of the following is an entirely new type of electron device that appeared within last twenty years:
   a hot-cathode vacuum diode, a photoemissive tube, a transistor
2. Which of the following relies for its operation on the movement of charge carriers through a semiconductor:
   an electron tube, a transistor, a gas-filled tube
3. Which of the following elements is most frequently used for transistors:
   germanium, silver, copper
4. Which of the following is produced by doping with pentavalent donor atoms:
   *p*-type germanium, *n*-type germanium, germanium
5. Which of the following is produced by doping with trivalent acceptor atoms:
   *n*-type germanium, *p*-type germanium, silicon
6. Which of the following devices does not need heating power:
   an electron tube, a transistor, a CRT

## Test 2

**I.** *Find Russian equivalents for the English verbs (see p. 148):*

| | |
|---|---|
| 1. replace | (a) вводить |
| 2. introduce | (b) позволять |
| 3. associate | (c) входить |
| 4. permit | (d) замещать |
| 5. cancel | (e) полагаться |
| 6. enter | (f) соединять |
| 7. rely | (g) уничтожать |
| 8. behave | (h) двигаться |
| 9. travel | (i) освобождаться |
| 10. liberate | (j) вести себя |

**II.** *Find Russian equivalents for the English words and word combinations (see p. 148):*

| | |
|---|---|
| 1. practically | (a) одновременно |
| 2. almost | (b) раньше, до, до тех пор, пока |
| 3. of course | (c) часто |
| 4. simultaneously | (d) в отличие |
| 5. before | (e) фактически |

| | |
|---|---|
| 6. frequently | (f) почти |
| 7. abruptly | (g) как следствие |
| 8. in contrast | (h) всецело |
| 9. as a consequence | (i) конечно |
| 10. entirely | (j) резко |

**III.** *Find Russian equivalents for the English words and word combinations (see p. 148):*

| | |
|---|---|
| 1. indeed | (a) если не |
| 2. in many respects | (b) действительно |
| 3. unless | (c) первоначально |
| 4. in comparison to | (d) вследствие, из-за |
| 5. initially | (e) наоборот |
| 6. just as | (f) кроме того |
| 7. due to | (g) немедленно |
| 8. conversely | (h) во многих отношениях |
| 9. furthermore | (i) как, когда |
| 10. immediately | (j) по сравнению с |

**IV.** *Find Russian equivalents for the English words (see p. 148):*

| | |
|---|---|
| 1. then | (a) чем |
| 2. although | (b) необходимо |
| 3. nearly | (c) очевидно |
| 4. necessarily | (d) относительно |
| 5. evidently | (e) через |
| 6. moreover | (f) благодаря |
| 7. due to | (g) затем |
| 8. than | (h) хотя |
| 9. relatively | (i) почти |
| 10. through | (j) кроме того |

**V.** *Find Russian equivalents for the English words and word combinations (see p. 149):*

| | |
|---|---|
| 1. in order to | (a) как раньше упоминалось |
| 2. already | (b) отчасти |
| 3. primarily | (c) для того, чтобы |
| 4. somewhat | (d) не взирая на |
| 5. regardless | (e) главным образом |
| 6. as mentioned earlier | (f) как в случае |
| 7. as in the case | (g) за исключением |
| 8. such | (h) подобно |
| 9. except | (i) такой |
| 10. like (*adv*) | (j) уже |

**VI.** *Match these synonyms (see pp. 149):*

| | |
|---|---|
| 1. often | (a) essential |
| 2. create | (b) each |
| 3. every | (c) encounter |
| 4. prevail | (d) moment |
| 5. important | (e) enlarge |
| 6. instant | (f) frequently |
| 7. meet | (g) build up |
| 8. procedure | (h) pair |
| 9. couple (*n*) | (i) process |
| 10. increase | (j) predominate |

**VII.** *Match these synonyms (see pp. 149):*

| | |
|---|---|
| 1. example | (a) collect |
| 2. gather | (b) furthermore |
| 3. associate | (c) consequently |
| 4. moreover | (d) instance |
| 5. immediately | (e) in order that |
| 6. therefore | (f) require |
| 7. rapid | (g) dissipate |
| 8. in order to | (h) fast |
| 9. necessitate | (i) connect |
| 10. diffuse | (j) at once |

## Test 3

*Find a synonym (a), (b), (c) or (d) to the word or word combination in bold type:*

1. To **cease** the flow of electrons — (a) permit; (b) result in; (c) result from; (d) stop

2. As we have **noted** that — (a) seen; (b) mentioned; (c) found; (d) stated

3. **In accordance with** this law — (a) because of; (b) thanks to; (c) according to; (d) regardless of

4. To **maintain** the flow of electrons — (a) allow; (b) accelerate; (c) control; (d) keep

5. **Although** the current is the same — (a) hence; (b) when; (c) though; (d) practically

6. It is **clear** that — (a) known; (b) found; (c) said; (d) evident

7. **Due to** the fact — (a) thanks to; (b) in spite of; (c) except for; (d) because of

8. **Free** charges — (a) positive; (b) negative; (c) moving; (d) loose

9. Some **varieties** of semiconductors — (a) materials; (b) kinds; (c) advantages; (d) disadvantages

10. To use **extensively** — (a) widely; (b) daily; (c) rarely; (d) at times

11. A **liberated** electron — (a) joined; (b) freed; (c) combined; (d) attached

12. A new **device** — (a) computer; (b) conductor; (c) appliance; (d) insulator

13. **On account of** that — (a) because of; (b) instead of; (c) by means of; (d) in spite of

14. To **remember** the following rule — (a) know; (b) explain; (c) mention; (d) keep in mind

15. As we **found out** — (a) said; (b) learned; (c) stated; (d) illustrated

16. As mentioned **earlier** — (a) previously; (b) later; (c) recently; (d) now

17. **Conventional** electron tubes — (a) new; (b) different; (c) common; (d) powerful

18. **Modern** machines — (a) various; (b) large; (c) up-to-date; (d) old

19. To **break** down a covalent bond — (a) create; (b) find; (c) change; (d) disrupt

20. To **affect** the plate current — (a) raise; (b) speed up; (c) influence; (d) change

## Test 4

*Finish each sentence choosing one of the three variants (a), (b) or (c) based on the texts from Section VI:*

1. A transistor is...
   (a) a conductor; (b) an electron tube; (c) a new type of electron device.
2. The transistor relies for its operation on the movement of...
   (a) atoms; (b) charge carriers; (c) molecules.
3. The most frequently used semiconductors in electronics are...
   (a) copper and brass; (b) iron and silver; (c) germanium and silicon.
4. In its outer shell germanium has...
   (a) four valence electrons; (b) no valence electrons; (c) two valence electrons.
5. When germanium is in crystalline form its atoms assume...

(a) a simple structure; (b) a complex structure; (c) a diamond structure.

6. The current conducting characteristics of the germanium crystal change radically when...
   (a) a small amount of impurity is introduced into it; (b) it has no impurities; (c) it has no excess of uncharged particles.
7. Germanium that has been doped by pentavalent donor atoms is known as...
   (a) *p*-type germanium; (b) an insulator; (c) *n*-type germanium.
8. An impurity that has three electrons in its outer shell is...
   (a) an impurity atom; (b) a donor atom; (c) an acceptor atom.
9. Germanium that has been doped with trivalent acceptor atoms is called...
   (a) *n*-type germanium; (b) unconducting material; (c) *p*-type germanium.
10. Conduction of electric current through *p*- or *n*-type germanium takes place...
    (a) in one direction; (b) in either direction; (c) in no direction.
11. The *p—n* junction is extensively used...
    (a) in batteries; (b) in junction diodes and transistors; (c) in resistors.
12. The battery connection that permits current to flow across the *p—n* junction is known as...
    (a) a reverse bias; (b) a grid bias; (c) a forward bias.
13. A transistor can function as...
    (a) an amplifier; (b) a condenser; (c) a transformer.
14. The junction that is forward biased in a transistor is always termed...
    (a) a collector junction; (b) an emitter junction; (c) a fused *p—n* junction.
15. The junction with a reverse bias in a transistor is called...
    (a) an emitter junction; (b) a fused *p—n* junction; (c) a collector junction.
16. The ratio of collector-to-emitter current is known as...
    (a) current gain; (b) voltage gain; (c) power gain.
17. The performance of transistors may be determined from...
    (a) characteristics of tubes; (b) characteristic curves of their voltage and current relations; (c) vacuum diode characteristic.

18. When the input voltage is increased the emitter current increases...
(a) rapidly; (b) slowly; (c) slightly.
19. The emitter current is always...
(a) more than the collector current; (b) less than the collector current; (c) equal to the collector current.
0. When transistors are operated as amplifiers it is possible to have...
(a) two basic circuit connections; (b) one basic circuit connection; (c) three basic circuit connections.
21. Regardless of the circuit connection the collector is always biased in...
(a) a negative bias; (b) a forward direction; (c) a reverse bias.
22. The emitter always has...
(a) a reverse bias; (b) a forward bias; (c) a negative bias.
23. The most flexible and efficient of the three basic connections is...
(a) the common-base connection; (b) the common-emitter circuit; (c) the common-collector connection.
24. The common-emitter connection produces...
(a) high input resistance; (b) no phase reversal; (c) a phase reversal.
25. The common-collector circuit is primarily used for...
(a) a signal amplifier; (b) impedance matching; (c) rectifying of the output signal.

*(See keys to the tests on pp. 149.)*

*Translate into Russian without a dictionary.*

TEXT

1. Atoms within a pure germanium or silicon crystals are strongly bound together by means of electron-sharing or covalent bonds in a diamond-like structure. Each germanium atom completes its outer valence shell by combining its four electrons in electron pairs with those of adjacent germanium atoms. A pure germanium crystal is practically an insulator.

2. When pure germanium is "doped" with atoms that have five electrons in their outer shell, the impurity or do-

nor atoms make their excess electrons available as negative charge carriers.

3. When pure germanium is "doped" with trivalent impurity, the impurity atoms or acceptors borrow electrons from surrounding germanium atoms, leaving a deficiency of electrons, or holes, in their place. The holes act like mobile, positive charge carriers.

4. Germanium doped with pentavalent donor atoms is called *n*-type germanium; current conduction takes place through negative charge carriers, or electrons. Germanium doped with trivalent acceptor atoms is called *p*-type germanium; current conduction takes place through positive charge carriers, or holes.

5. When a *p—n* junction is biased in the forward direction, by applying a positive potential to the *p*-region and negative potential to the *n*-region, the holes and electrons are repelled toward the junction area and overcome the potential barrier there. Current conduction then takes place by means of electron-hole combinations in the vicinity of the junction.

6. With reverse bias applied to a *p—n* junction, holes and electrons are attracted away from the junction area, and current conduction stops except for a small reverse current. If the reverse bias is made very high, the junction breaks down, and a relatively large reverse current flows.

7. A junction triode transistor is a sandwich made up of two *p—n* junctions, either in *p—n—p* form or *n—p—n* form. The central region is called the base and the two outer layers are called the emitter and collector, respectively.

8. The emitter junction of a transistor is always biased in a forward direction, while the collector junction is biased in reverse direction. The collector current in a junction transistor is less than the emitter current by an amount proportional to the number of electron-hole combinations occurring in the base area.

9. Current conduction in a *p-n-p* transistor takes place by hole conduction from emitter to collector, while current conduction in a *n-p-n* transistor is carried on by electrons as majority charge carriers.

10. The ratio of collector-to-emitter current is known as current gain or alpha and is always less than 1. Transistors may be connected into either of three basic circuits. There are: 1. common-base; 2. common-emitter; and 3. common-collector.

The common-base connection provides a very low input resistance, a high output resistance, and a current gain of less than 1. There is no phase reversal.

The common-emitter connection, the most flexible and efficient of the three basic connections, reverses the phase of the output signal with respect to the input. Its input resistance is higher and its output resistance is lower than those of the common-base connection, but it provides the highest voltage and power gain.

The common-collector connection is the transistor that is used primarily as a buffer and for impedance matching. The connection provides a high input resistance, a low output resistance and a voltage gain of less than 1.

3000

## SECTION SEVEN

### I.

### Pronunciation Drill 1

*Practise the sound* [aɪə]:

fire, wire, require, desire, desirable, variety, amplifier

### Pronunciation Drill 2

*While reading these words pay attention to the stress markings:*

| ● • | ● • • | • ● • |
|---|---|---|
| knowledge | magnitude | resistor |
| other | similar | essential |
| level | frequency | inductor |

### TEXT 17

## AMPLIFIERS

1. We are finally ready to apply the knowledge we gained in previous sections about electrons, vacuum tubes and transistors to some practical matters.[1] In the following sections we shall consider a variety of circuits employing electron tubes and transistors. Circuits are combinations of tubes or

transistors with other components, such as resistors, capacitors and inductors, and form the basic building blocks of electronic systems: radio, automatic computer and so on. To understand the systems, you must be familiar with the circuits that make them up.

2. In this section we shall discuss amplifier circuits, or more specifically, audio amplifiers. An amplifier is an electron tube or transistor circuit, which builds up an ac signal applied to its input. It is called a voltage amplifier if the magnitude of the output voltage from the amplifier is considerably greater than that of the input voltage. As a matter of fact the ratio of the output voltage to the input voltage is called the amplification or gain of the amplifier.

3. There are also so-called power amplifiers. These are similar to voltage amplifiers, except that their main purpose is to supply a considerable amount of power i. e. voltage times current to the output or load circuit, although the ac input signal may not draw any grid current and, hence, the input power may be zero.

4. When a number of amplifiers are hooked up in series so that the output of one serves as the input to the next amplifier stage, the function of the early stages is usually to build up the voltage to a high level, while the last stage builds up the power to a level sufficient to operate an output device. Audio amplifiers amplify electrical ac signals that have a frequency range corresponding to the range of human hearing, or from about 20 to 15,000 cycles per second.

*(to be continued)*

1500

## Commentary

1. to some practical matters — на практике

### EXERCISES

**I.** *Review questions:*

1. What do often electronic systems involve? 2. What is an amplifier? 3. What is a voltage amplifier? 4. What is the amplification or gain of the amplifier? 5. What is the main purpose of power amplifiers? 6. In what way are a number of amplifiers connected? 7. What do audio amplifiers amplify?

**II.** *Make up an abstract of the text basing on the answers to the above questions.*

**III.** *Define to what parts of speech these words belong and translate them:*

user, usage, misuse, useful, useless, usefulness, uselessness, usefully, uselessly; various, variously, variable, variation, variety; converter, reconvert, conversion, conversely

**IV.** *Translate these synonyms and memorize them:*

1. magnitude (*n*), value, size, largeness, meaning
2. understand (*v*), realize
3. make up (*v*), constitute, form, build up
4. considerably (*adv*), very, greatly, substantially
5. calculate (*v*), compute
6. sufficient (*adj*), enough
7. purpose (*n*), goal, aim, objective
8. matter (*n*), affair, business
9. similar (*adj*), alike, the same as
10. as a matter of fact, in fact, in effect

**V.** *Brush up these words and word combinations:*

as a matter of fact, except that, finally, in turn, such as, and so on, a number of, while, considerably, similar

## II.

### Pronunciation Drill 1

*Practise the sound* [ɛə]*:*

vary, variable, compare, apparent, share, pair, ampere, where, there, square, care, fairly, area, rare

### Pronunciation Drill 2

*While reading these words pay attention to the stress markings:*

| • ● | ● • | • ● • | ● • • |
|---|---|---|---|
| appear | moment | insertion | introduce |
| distort | under | dynamics | represent |
| avoid | practice | example | overcome |

## AMPLIFIERS
*(Continued)*

1. The simple triode amplifier is illustrated in Fig. 17. Let us see what happens under dynamic conditions when

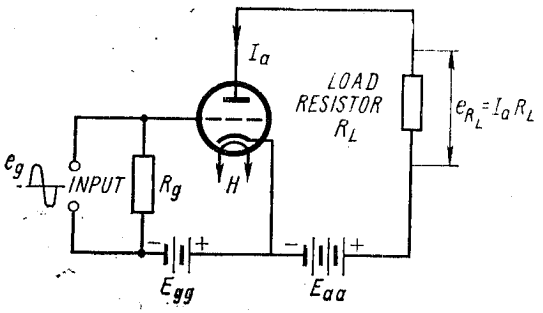


Fig. 17. Basic triode amplifier circuit and notations

an actual ac signal voltage $e_g$ is applied to the input of the amplifier. The plate current in a triode is determined by the electrostatic field resulting from the combined action of the grid and plate potentials.

2. Since the grid is placed closer to the cathode than the plate, the grid voltage has a greater effect on the amount of plate current than the plate voltage. Thus, if the grid voltage is made more negative by a fixed number of volts, the plate current is reduced far more than the same decrease in plate voltage would produce.[1]

3. When a resistance load is placed in series with the plate circuit, the voltage drop produced across this resistance is a function of the plate current and, hence, is controlled by the grid voltage. Thus, a tiny change in the grid voltage can cause a large change in the plate current and in the resulting voltage across the load resistance. In other words, the signal voltage appearing at the grid is amplified in the plate circuit of the tube.

4. Let an ac signal voltage be equal to 6 volts peak amplitude. It is introduced in the grid circuit in series with a fixed bias voltage $E_{cc}$ from 6-volt battery. To understand the purpose of the bias voltage assume for a moment, that it isn't there, and the 6-volt signal voltage is applied to the

grid alone. The voltage on the grid of the tube will then vary between zero +6 volts, and —6 volts, as the ac signal goes through one cycle.

5. Whenever the input signal goes positive and hits its +6 volt peak value, a grid current will flow out from the grid of the tube. This grid current not only distorts the linearity of the tube's characteristic curves, thus leading to distorted amplifications, but it also requires a certain amount of power i.e. grid voltage times grid current, which it extracts from the input signal. If the input signal is too weak to supply the power, further distortion takes place, with undesirable results.

6. To avoid the distortion and consuming power in the grid circuit it is essential, therefore, that no grid current should flow during any portion of the ac input signal. This then is the function of the bias voltage. The bias voltage in a voltage amplifier is always of sufficient magnitude and of such polarity as to maintain the grid negative or at zero volts during the positive peak of the ac input signal.

7. The total instantaneous voltage between grid and cathode of the tube symbolized $e_c$ is equal to the algebraic sum of the ac signal voltage and the dc grid bias. Thus,

$$e_c = E_{gg} + e_g.$$

In our example, since $E_{gg} = -6$ volts and the signal voltage $e_g$ varies between +6 and —6 volts, the total instantaneous grid voltage $e_c$ will vary between 0 and —12 volts. Grid resistor $R_g$ acts as a grid return[2] for the bias voltage of the $E_{gg}$ battery.

8. In practice battery $E_{gg}$ is not often used. The fixed grid bias obtained by the method known as self-bias,[3] makes use of the insertion of appropriate resistors in the cathode circuit. Plate current flowing through the cathode resistor will develop the necessary drop to bias.

2600

## Commentary

1. than the same decrease in plate voltage would produce — чем при таком же уменьшении анодного напряжения
2. as a grid return — как сеточный отвод
3. as self-bias — как автоматическое смещение

## EXERCISES

**I.** *Review questions:*

1. What is the plate current in a triode determined by? 2. By what is the voltage drop determined across a load resistor connected in series with the plate circuit? 3. Where is the signal voltage amplified? 4. When does further distortion with undesirable results take place? 5. What is essential for avoiding the distortion? 6. What is the total instantaneous voltage between grid and cathode of the tube equal to? 7. What method is the fixed grid bias obtained by?

**II.** *Make up an abstract of the text basing on the answers to the above questions.*

**III.** *Translate the international words without a dictionary:*
to extract, to induce, to start, to pulsate

**IV.** *Define what parts of speech these words are and translate them:*

distortion, distortionless; opposite, opposed, opposition; discontinue, continuous, continuance, continually; expression, expressive, expressively; desirable, undesirable

**V.** *Translate these synonyms and memorize them:*

1. desire *(v)*, want, wish
2. avoid *(v)*, escape, avert, evade
3. total *(adj)*, entire, complete, whole
4. should *(v)*, must
5. assume *(v)*, suppose
6. extract *(v)*, draw out
7. vary *(v)*, change, differ, alter
8. condition *(n)*, circumstance
9. appropriate *(adj)*, suitable, proper
10. since *(conj)*, as, for

**VI.** *Brush up these words and word combinations:*

under any conditions, then, since, far more, thus, whenever, therefore, let us, though, close

## III.

### Pronunciation Drill 1

*Practise the sound* [ʃn]:

application, operation, discussion, emission, situation, conduction, junction, extension, conventional, connection, sufficient, efficient, expression

## Pronunciation Drill 2

*While reading these words pay attention to the stress markings:*

| • ● • | ● • • | •●•• |
|---|---|---|
| expression | negative | identify |
| reversal | maximum | additional |
| distortion | linear | capacitor |

### TEXT 19

## PLATE CIRCUIT OF THE AMPLIFIER

1. Let's see now what happens in the plate circuit of the tube, while the grid-to-cathode voltage goes through its cycle from 0 to —12 volts. The plate current will continue to flow as long as the ac signal voltage is not sufficiently large to drive the tube to plate-current cut-off.

2. The bias, signal voltage and plate-supply voltage $E_{aa}$ in our example in Fig. 17 have been so chosen that the tube does not reach plate-current cut-off, even for the most negative value of the grid voltage. Plate current will, therefore, flow at all times during the ac input signal cycle.[1] As a matter of fact, this is a necessary condition for all voltage amplifiers to obtain linear, distortionless amplification.

3. With plate current $I_a$ flowing at all times, a voltage drop is produced across load resistor $R_L$ in the plate circuit. The voltage drop across this fixed load resistor depends on the value of the plate current and the plate current, in turn, is controlled by the grid voltage.

4. Because of the amplifying action of the tube, a small change in the signal or grid voltage produces a large change in the plate current and, hence, in the voltage across the load resistor. By making the load resistance sufficiently high a large voltage drop is produced across it, resulting in high voltage amplification.

5. Amplification, or gain, is the ratio of the output voltage across the load to the input signal voltage. A large load voltage and, hence, high amplification, may be obtained even with quite small plate currents, since there is no theoretical limit for the size of the load resistor.

6. Total plate current consists of two components, one dc and one varying like the grid voltage $e_c$. The dc compo-

nent of the plate current, identified as $I_a$, is the normal plate current that flows with the plate voltage and bias applied, but with the ac input signal voltage $e_g$ absent. The ac component of the plate current identified as $i_a$, on the other hand, is the variation in the total plate current caused by the ac input signal at the grid.

7. Note further that in Fig. 17 the bottom of the load resistor is more negative than the top or battery-connected end.[2] The load voltage, thus, is in opposition to the plate supply voltage, and since it is connected in series with it, subtracts from it. The greater the plate current, the greater is the load voltage and, hence, the less plate supply voltage is left over to reach the plate of the tube. The total instantaneous voltage on the plate identified by $e_a$ therefore, is the difference between the plate-supply voltage, $E_{aa}$, and the voltage across the load, $e_{R_L}$, expressed mathematically, total instantaneous plate voltage

$$e_a = E_{aa} - i_a R_L.$$

8. From the above expression it is clear, that the total plate voltage at any instant becomes smaller as the plate current becomes larger. Furthermore, since the plate current increases directly, with the input signal voltage, the total plate voltage decreases with increasing grid or signal voltage. Thus the plate voltage $e_a$ is a maximum when the grid voltage $e_c$ is a minimum, and vice versa.

9. The grid and plate voltages, therefore, are in phase opposition,[3] or equivalently, the tube is said to produce a 180-degree phase reversal[4] of the plate voltage with respect to the grid voltage. The output voltage from a single amplifier stage may not be sufficient to be applied directly to an output device.

10. Additional amplification over two or more stages is usually necessary. To accomplish this the output voltage of each amplifier stage must be coupled in some way to the grid of the succeeding amplifier tube.

11. Resistance or $RC$ coupling is the most popular of all coupling methods. In this case the ac component of the first tubes output voltage is coupled to the grid of the following stage through a coupling capacitor $C$. This capacitor prevents the dc plate voltage of the first tube from the reaching the grid of the second tube, and, thus overloading it.

## Commentary

1. during the ac input signal cycle — в течение периода входного сигнала

2. the bottom of the load resistor is more negative than the top or battery-connected end — нижний конец нагрузочного сопротивления более отрицательный, чем верхний, связанный с батареей конец

3. in phase opposition — в противофазе

4. a 180-degree phase reversal — изменение фазы на 180°

## EXERCISES

**I.** *Review questions:*

1. What condition is necessary for all voltage amplifiers to obtain linear, distortionless amplification? 2. What does the amount of voltage amplification primarily depend on? 3. With what currents may high amplification be obtained? 4. What components does the plate current consist of? 5. What is the total instantaneous plate voltage? 6. When does the plate voltage reach maximum? 7. What voltages are in phase opposition? 8. How is additional amplification accomplished?

**II.** *Make up an abstract of the text basing on the answers to the above questions.*

**III.** *Define the meanings of the suffixes and prefixes in the following words and translate the words:*

theoretician, theoretical, theoretically; leader, mislead, leadership, leading; operator, operation, operative, operatively; proportion, disproportion, proportionless, disproportionless; length, lengthen; width, widen; strength, strengthen; depth, deepen

**IV.** *Translate these antonyms and memorize them:*

1. remember *(v)*, forget
2. subtract *(v)*, add
3. output *(n)*, input
4. last *(adj)*, first
5. top *(n)*, bottom
6. drop *(n)*, rise
7. presence *(n)*, absence
8. increase *(v)*, lessen, reduce
9. total *(adj)*, partial
10. difference *(n)*, similarity

**V.** *Brush up these word combinations:*

as long as, in this case, vice versa, sufficiently, with respect to, furthermore, on the one hand, on the other hand, in some way, for

## IV.

### Pronunciation Drill 1

*Practise the sound* [ tʃə ]:

picture, future, temperature, mixture, nature, structure, manufacture, miniature, saturation

### Pronunciation Drill 2

*While reading these words pay attention to the stress markings:*

| ● • | ●• • | • ● • |
|---|---|---|
| latter | diagram | acceptance |
| valve | typical | pulsation |
| absence | practical | outstanding |

**TEXT 20**

## TRANSISTOR AMPLIFIER

1. In recent years transistor amplifiers have gained wide acceptance in all branches of electronics. The outstanding advantage of these circuits is that no heater voltage supply is required and that a small, low-current dc source takes care of all transistor current needs, thus making battery operation quite economical. There are three types of semiconductor amplifiers, namely: common-base, common-collector and common-emitter amplifiers. Of these the latter is the most popular.

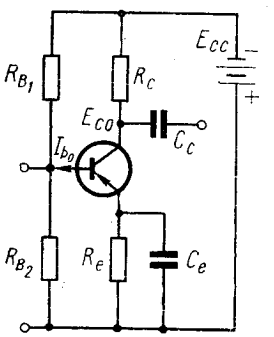


Fig. 18. Transistor common-emitter amplifier stage

2. The current in Fig. 18 illustrates a typical stage of the common-emitter connection transistor amplifier.[1] In this diagram resistors $R_{B1}$, $R_{B2}$ and $R_c$ provide the required bias to the collector and base.

Resistor $R_e$ is employed to reduce the variation of the collector current with temperature. Capacitor $C_c$ is coupling capacitor between stages, and capacitor $C_e$ serves to bypass resistor $R_e$. Without $C_e$ in the circuit, the presence of $R_e$ would result in a reduced amplification.

3. Consider the operation of such an amplifier. First, let us suppose that there is no input signal. Direct current $I_{bo}$ is flowing in the base circuit, while direct current $I_{co}$ is in the collector. The collector voltage $E_{co}$ is of a constant magnitude. The alternating input voltage appearing, its variable component induces pulsations of the base current. The changing base current in its turn makes the collector current pulsate. This induces corresponding pulsations of the collector voltage, which come to the circuit output via capacitor $C_c$.

4. In case a low-voltage transistor is used in the circuit, the alternating base current will be in the order of scores of microamperes, while the alternating collector current will be in the order of milliamperes. Thus a low input current controls a high output current, amplifying the input signal.

5. Thus, in the absence of the input signal the transistor base and collector carry direct currents, their value being determined by the resistance offered by the circuits. Once the input signal is applied, the base current starts to change in the wake of[2] the input signal, producing corresponding changes in the collector voltage and current.

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## Commentary

1. of the common-emitter connection transistor amplifier — транзисторного усилителя, собранного по схеме с общим эмиттером

2. in the wake of — вслед за, непосредственно за

## EXERCISES

**I.** *Review questions:*

1. What advantages have transistor amplifiers? 2. What are the three types of semi-conductor amplifiers? 3. Which one is the most popular? 4. What is the output and input signal of the transistor amplifier?

**II.** *Make up an abstract of the text basing on the answers to the above questions.*

**III.** *Define to what parts of speech the following words belong and translate them:*

consumer, consumption; reliable, reliability; universal, universally; pulsate, pulsation; resistor, resistable, irresistible; disorder, disorderly; uncommon, commonly; needless, needful, needy; economize, economization, economist, economic, economically; corresponding, correspondence

**IV.** *Translate these synonyms and memorize them:*

1. outstanding *(adj)*, prominent, well-known
2. recent *(adj)*, last
3. induce *(v)*, bring about, produce, cause
4. suppose *(v)*, think, assume
5. consume *(v)*, use
6. offer *(v)*, propose, give
7. need *(n)*, requirement, want, necessity
8. power *(n)*, energy
9. recognition *(n)*, acceptance, acknowledgement
10. attain *(v)*, reach, achieve, get, obtain, acquire

**V.** *Translate these words and word combinations and learn them:*

namely, the former, the latter, first, in its turn, via, once, in case, without, recent

## Test 1

*Find the correct answer out of the three given to each question:*

1. Which of the devices builds up an ac signal applied to its input:
   an amplifier, a rectifier, an oscillator
2. How do the input signal and output signal depend on each other:
   in phase, out of phase, in phase of 90°
3. Which of the following is amplified in the plate circuit of the tube:
   a bias voltage, a grid cut-off voltage, a signal voltage
4. Which of the following may be obtained with quite small plate currents:
   high amplification, low amplification, distortion
5. Which of the following devices has gained wide acceptance in all branches of electronics in recent years:
   a transistor amplifier, a gas-filled tube amplifier, a tube amplifier

## Test 2

**I.** *Find Russian equivalents for the English words and word combinations (see p. 149):*

| | |
|---|---|
| 1. finally | (a) как например |
| 2. such as | (b) ряд, несколько |
| 3. as a matter of fact | (c) поочередно |
| 4. a number of | (d) подобный |
| 5. similar | (e) за исключением того, что |
| 6. in turn | (f) значительно |
| 7. except that | (g) фактически |
| 8. and so on | (h) в то время как |
| 9. considerably | (i) и т. д. |
| 10. while | (j) наконец |

**II.** *Find Russian equivalents for the English words and word combinations (see p. 149):*

| | |
|---|---|
| 1. close (*adj*) | (a) хотя |
| 2. therefore | (b) так как; с тех пор, как; с |
| 3. though | (c) близкий |
| 4. since | (d) при любых условиях |
| 5. under any conditions | (e) затем |
| 6. let us | (f) значительно больше |
| 7. then | (g) таким образом |
| 8. thus | (h) всякий раз когда |
| 9. whenever | (i) давайте |
| 10. far more | (j) поэтому |

**III.** *Find Russian equivalents for the English words and word combinations (see p. 149):*

| | |
|---|---|
| 1. as long as | (a) в этом случае |
| 2. in this case | (b) наоборот |
| 3. vice versa | (c) кроме того |
| 4. with respect to | (d) пока |
| 5. furthermore | (e) с другой стороны |
| 6. on the one hand | (f) за; для; в течение; так как |
| 7. on the other hand | (g) достаточно |
| 8. in some way | (h) каким-нибудь образом |
| 9. for | (i) с одной стороны |
| 10. sufficiently | (j) относительно |

**IV.** *Find Russian equivalents for the English words and word combinations (see p. 149):*

| | |
|---|---|
| 1. namely | (a) первый из упомянутых выше |
| 2. the former | (b) в свою очередь |
| 3. the latter | (c) а именно |
| 4. in its turn | (d) недавний, новый |
| 5. recent | (e) без |
| 6. once | (f) через |
| 7. without | (g) в случае если |
| 8. in case | (h) сначала |
| 9. via | (i) однажды |
| 10. first | (j) последний из упомянутых выше |

**V.** *Match these synonyms (see pp. 149):*

| | |
|---|---|
| 1. acceptance | (a) energy |
| 2. offer | (b) want |
| 3. power | (c) real |
| 4. need (*n*) | (d) enough |
| 5. attain | (e) recognition |
| 6. actual | (f) the same as |
| 7. sufficient | (g) business |
| 8. calculate | (h) compute |
| 9. similar | (i) achieve |
| 10. matter | (j) propose |

**VI.** *Match these antonyms (see p. 149):*

| | |
|---|---|
| 1. remember | (a) add |
| 2. output | (b) bottom |
| 3. first | (c) rise |
| 4. top | (d) reduce |
| 5. subtract | (e) partial |
| 6. drop (*n*) | (f) forget |
| 7. presence | (g) similarity |
| 8. increase | (h) last |
| 9. total | (i) absence |
| 10. difference | (j) input |

## Test 3

*Find a synonym (a), (b), (c) or (d) to the word or word combination in bold type:*

1. The main **purpose** — (a) problem; (b) question; (c) goal; (d) point

2. To **avoid** using this device — (a) evade; (b) stop; (c) continue; (d) begin

3. **Since** this value is equal to — (a) hence; (b) as; (c) in this case; (d) when

4. To **understand** the question — (a) realize; (b) answer; (c) put; (d) ask

5. To be **greatly** extended — (a) slowly; (b) rapidly; (c) considerably; (d) really

6. To **make up** a circuit — (a) close; (b) form; (c) break; (d) disconnect

7. A **recent** report — (a) last; (b) new; (c) old; (d) good

8. To **change** the frequency range — (a) shorten; (b) lengthen; (c) limit; (d) vary

9. To **calculate** the losses — (a) increase; (b) reduce; (c) compute; (d) utilize

10. The same **conditions** — (a) values; (b) positions; (c) circumstances; (d) places

11. **As a matter of fact** this value is — (a) in case; (b) on the other hand; (c) therefore; (d) in fact

12. This value **should** be determined — (a) can; (b) must; (c) may; (d) will

13. The **magnitude** of the current — (a) flow; (b) value; (c) output; (d) input

14. The **entire** voltage — (a) low; (b) any; (c) total; (d) amplified

15. A **suitable** material — (a) proper; (b) useful; (c) necessary; (d) good

16. **Similar** questions — (a) different; (b) easy; (c) difficult; (d) the same

17. Let us **assume** that — (a) suppose; (b) say; (c) see; (d) find

18. A strong **desire** — (a) will; (b) belief; (c) impression; (d) wish

19. The **outstanding** fact — (a) prominent; (b) real; (c) unknown; (d) same

20. The power was **consumed** — (a) induced; (b) used; (c) transferred; (d) transmitted

## Test 4

*Finish each sentence choosing one of the three variants (a), (b) or (c) based on the texts from Section VII:*

1. Combinations of tubes with resistors, capacitors and inductors make...
   (a) circuits; (b) triodes; (c) diodes.
2. Electronic systems are formed of...
   (a) instruments; (b) insulators; (c) circuits.
3. The essential element of an amplifier is...

(a) an electron tube or a transistor; (b) a convertor of an alternating current into a direct current; (c) a resistor and a condensor connected in series.

4. An ac signal amplifier amplifies...

(a) an ac signal applied to its input; (b) a dc signal applied to its input; (c) an ac signal applied to its output.

5. An amplifier is called a voltage amplifier if the magnitude of the output voltage from it is...

(a) considerably lower than that of the input voltage; (b) considerably greater than that of the input voltage; (c) exactly the same as the input voltage.

6. The ratio of the output voltage to the input voltage is called...

(a) the distortion of the input signal; (b) the amplification or gain of the amplifier; (c) the dumping of the output signal.

7. Audio amplifiers amplify...

(a) vidio signals; (b) electrical dc signals; (c) electrical ac signals.

8. Audio signals have a frequency range from...

(a) 0 to 15 cycles per second; (b) about 20 to 15,000 cycles per second; (c) 20,000 to 40,000 cycles per second.

9. The signal voltage appearing at the grid is amplified in...

(a) the filament circuit of the tube; (b) the source of the plate voltage; (c) the plate circuit of the tube.

10. To avoid the distortion and consuming power in the grid circuit it is essential that...

(a) no grid current should flow during any portion of the ac input signal; (b) the grid current should be high during any portion of the ac output signal; (c) the grid current should flow during the positive portion of the ac input signal.

11. The total instantaneous voltage between the grid and the cathode of the tube is equal to...

(a) the algebraic sum of the ac signal voltage and the dc grid bias; (b) the algebraic difference of the ac signal voltage and the dc grid bias; (c) the input signal.

12. The plate current flowing through the cathode resistor will develop...

(a) the necessary increase of the plate voltage; (b) the necessary drop to bias; (c) the sharp changing of heating voltage.

13. The total plate voltage becomes...

(a) smaller as the plate current becomes larger;

(b) smaller as the plate current becomes smaller; (c) the same when the plate current becomes larger.

14. The plate voltage is...
(a) a minimum when the grid voltage is a minimum; (b) a maximum when the grid voltage is a minimum; (c) a maximum when the grid voltage is also a maximum.

15. In recent years transistor amplifiers...
(a) came out of use; (b) were not known; (c) have gained wide acceptance.

16. There are...
(a) three types of semiconductor amplifiers; (b) two types of semiconductor amplifiers; (c) four types of semiconductor amplifiers.

17. The most popular semiconductor amplifier is...
(a) common-base; (b) common-emitter; (c) common-collector.

18. The outstanding advantages of the transistor amplifiers are...
(a) high reliability and low power consumption; (b) high reliability and high power consumption; (c) the requirement of high heating voltage.

19. Both in the tube and transistor amplifiers the input signal and the output signal are...
(a) 90 degrees out of phase; (b) 180 degrees out of phase; (c) in phase.

20. The plate current is...
(a) in phase with the input signal; (b) out of phase with the output signal; (c) 180 degrees out of phase with the output signal.

*(See keys to the tests on p. 149)*

*Translate into Russian using a dictionary*

## * FEEDBACK AMPLIFIERS

1. Feedback means transferring a portion of the energy from the output of amplifier back to its input. It has been found eminently useful in reducing distortion caused within amplifiers and making amplifier operation more stable in respect to variations in gain due to line-voltage changes, tube differences, ageing, etc.

2. There are two basic types of feedback: regenerative or positive feedback and negative feedback. When the feedback

energy is in phase with the applied signal, regenerative or positive feedback takes place. Negative feedback is the term used, when the feedback signal is out of phase with the applied signal.

3. Regenerative feedback increases the gain of an amplifier. In contrast, negative feedback decreases the gain, as well as the distortion of an amplifier, and for the latter reason, we shall be primarily interested in negative feedback. The gain of the amplifier in the presence of negative feedback:

$$K = -\frac{A}{1 + \beta A},$$

where $A$ is the gain of the amplifier without feedback, $\beta$ is the feedback fraction.

4. When the feedback factor $\beta A$ is made large compared to 1, the previous expression becomes

$$K = -\frac{1}{\beta}.$$

The gain of the amplifier in this case is quite small, but depends only on the feedback fraction $\beta$ and is thus substantially independent of the actual gain $A$ of the amplifier.

5. As a result, the gain of an amplifier with large negative feedback is extremely stable and is practically independent of fluctuations in the supply voltage and ageing of tubes. Moreover, since the gain depends only on the feedback fraction $\beta$, the variation in gain with frequency or the frequency response is entirely controlled by the nature of $\beta$.

6. If the feedback fraction is obtained through a resistive network, the feedback, and hence the gain, does not vary with frequency. The frequency response of an amplifier may thus be considerably improved by using large amounts of negative feedback.

7. Hum, noise and distortion introduced within an amplifier are reduced with negative feedback by the same factor $1+\beta A$ as the gain. Since the loss in gain can always be compensated for by increasing the amplitude of the input signal, the net effect of negative feedback is a reduction in distortion, noise and hum.

2000

*(See the Russian translation of this text on pp. 151.)*

# Texts for Additional Reading (Sections VIII—X)

## SECTION EIGHT

### ELECTRON TUBE OSCILLATORS

1. An oscillator is an energy converter which changes direct-current energy into alternating-current energy. Because of their ability to amplify, electron tubes and transistors are very efficient energy converters, and are for this reason universally used as electrical oscillators.

2. If the damped oscillations occurring in a resonant circuit containing inductance and capacitance are applied to the input of an amplifier, the output current varies in accordance with the input signal, resulting in an amplified reproduction of the oscillations. Because of this amplification, more energy is available in the output circuit than in the input circuit.

3. If part of this output energy could be fed back by some means to the input circuit in the proper phase to aid the oscillations of the resonant $L - C$ circuit, its losses would be overcome and sustained, undamped oscillations would take place. This is in fact accomplished by a regenerative feedback circuit, which permits the combination of amplifier and resonant $L - C$ circuit to function as a continuous self-sustaining oscillator. Now we consider in details the work of the electron tube oscillator circuit.

4. To produce electrical oscillations with an electron tube the following elements must be present: (1) An oscillatory or resonant circuit, containing inductance $L$ and capacitance $C$ to determine the frequency of oscillation. Such a circuit is called a tank circuit. (2) A source of dc energy to replenish losses in the tank circuit. (3) A feedback circuit for supplying energy from the source in the right phase to aid the oscillations, i.e. regenerative feedback.

5. An electron tube can function as an oscillator, if it has sufficient amplification and if a sufficient amount of energy is fed back to the tank to overcome all circuit losses. If the losses in the plate and the tank circuit are completely overcome, the effective circuit resistance is zero, and oscillations take place.

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## TICKLER FEEDBACK CIRCUIT

1. One of the earliest electron tube oscillator circuits is the so-called tickler feedback oscillator. In Fig. 19, the oscillatory tank circuit is made up of $L1$, and $C1$, the source of dc energy is the plate supply voltage, $E_{aa}$ and the feedback circuit consist of the "tickler" coil $L$, which is coupled to $L1$.

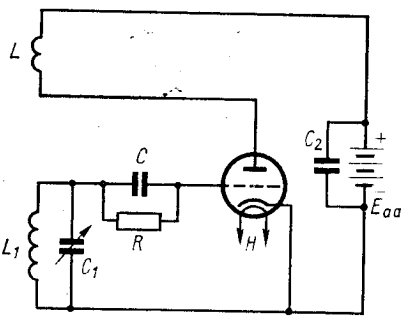


Fig. 19. Tickler feedback oscillator circuit

2. Capacitor $C1$ is made variable to adjust the frequency of the oscillations. The bypass capacitor $C2$ is placed across the battery to provide a low-reactance path for the alternating component of the plate current. The combination of $R$ and $C$ in the grid circuit is called the grid leak, and its function is to furnish a self-adjusting negative bias to the tube.[1]

3. Once oscillations have been started in the tank circuit $L1 - C1$, they will appear in amplified form in the plate circuit of the tube. Part of the energy is fed back from tickler coil $L$ to tank coil $L1$ by mutual induction, thus overcoming losses and sustaining the oscillations.

4. The tube itself introduces a phase shift of 180° between grid and plate circuit. The combination of $L$ and $L1$ constitutes a transformer, and consequently, another phase shift of 180° takes place between the plate and grid circuit. As a result, the voltage feedback is in phase with the voltage in the grid circuit, and regenerative or positive feedback takes place.

5. The moment when the key is closed, plate current be-

gins to flow through the tube and through the external circuit, consisting of the tickler coil $L$ and the battery. This current sets up an expanding magnetic field around the tickler coil $L$ and so induces a voltage in the tank coil $L1$.

6. Assume that the initial induced voltage is positive so that the upper end of the $L1 - C1$ tank circuit is of positive polarity. This positive voltage charges the capacitor $C1$ and places a positive charge on the grid of the tube which is connected to the upper end of $L1 - C1$.

7. Since the grid has initially no bias, this positive charge increases the plate current and thus further builds up the magnetic field around the tickler coil $L$. As a result, a still larger positive voltage is induced in $L1$ and placed on the grid, and $C1$ is further charged.

8. Again the plate current keeps rising and the field of $L$ expands, placing a still greater positive voltage on $C1$ and the grid. Theoretically, this process continues until the plate current reaches its saturation point and tapers off. At that instant the field about coil $L$ stops expanding and becomes static.

9. As the magnetic field about coil $L$ stops expanding, the voltage induced in $L1$ begins to drop and finally reaches zero. Now, however, capacitor $C1$, which has been charged to the maximum positive voltage begins to discharge in the opposite direction, making the upper portion of $L1 - C1$ negative.

10. As the potential on the upper end of $L1 - C1$ is reduced from its positive value to zero and then becomes negative, the voltage on the grid is equally reduced, thus lowering the plate current. As the plate current decreases, the field about $L$ starts contracting and induces a negative voltage in $L1$. This leads to a further discharge of capacitor $C1$ and a still greater negative grid voltage.

11. As the negative charge on the grid increases, the plate current drops more and more, until finally it is cut off. At this instant the field about $L$ is completely collapsed, the voltage induced in $L1$ disappears, and the grid voltage rises to zero. Since the grid is now less negative than the value it had at cut-off, the plate current increases again, and entire cycle is repeated.

12. The grid-leak resistor $R$ and grid capacitor $C$ in Fig. 19 furnish the negative bias required for the tube's operation. Capacitor $C$ is large enough to provide a low-resistance path to the grid for the excitation signal, and thus bypasses the high-resistance grid leak $R$.

13. In operation the grid is driven positive during half-cycles of the oscillations and, therefore, draws grid current. The electron current flows from the cathode to the grid and then through the external circuit consisting of $L1$ and $R$, thus developing a voltage drop across $R$. The end of $R$ connected to the grid is made more negative than the other end, and the grid is then biased negatively by an amount equal to the voltage drop across $R$.

14. The voltage present across $R$ during grid-current flow charges capacitor $C$. If $R$ and $C$ are sufficiently large, the charge on $C$ will leak off only very slowly during negative half-cycles, when no grid-current flows. Hence, for all practical purposes, the voltage across $C$ remains constant throughout a complete cycle, and maintains a steady bias on the tube.



## Commentary

1. to furnish a self-adjusting negative bias to the tube — создать автоматическое отрицательное смещение для лампы

## Test

*Finish each sentence choosing one of the three variants (a), (b) or (c) based on the texts from Section VIII:*

1. An oscillator acts as...
   (a) an energy converter; (b) a rectifier; (c) an amplifier.
2. An oscillator changes...
   (a) alternating current energy into direct-current energy; (b) direct-current energy into alternating-current energy; (c) low frequency into high frequency.
3. An oscillator always involves...
   (a) a negative feedback circuit; (b) a rectifying circuit of ac output signal; (c) a positive feedback circuit.
4. If the damped oscillations occurring in a resonant circuit are applied to the input of an amplifier...
   (a) the output current varies in accordance with the input signal; (b) the output current does not vary; (c) the input current is not reduced.
5. An oscillatory tank circuit, a source of dc energy and a feedback circuit are essential parts of...

(a) a triode oscillator; (b) a mechanical oscillator; (c) an audio amplifier.

6. Oscillatory tank circuits which contain inductance and capacitance...
   (a) determine the frequency of oscillators; (b) replenish losses; (c) are sources of energy.
7. A source of dc energy...
   (a) determines the frequency of oscillations; (b) replenishes losses; (c) consumes dc energy.
8. A feedback circuit...
   (a) replenishes losses; (b) determines frequency; (c) aids oscillations.
9. An electron tube can function as an oscillator...
   (a) if it has sufficient amplification and if a sufficient amount of energy is fed back to the tank; (b) if the amplification is low; (c) if the amount of energy fed back is insufficient to overcome the circuit losses.
10. If the losses in the plate and the tank circuit are completely overcome...
    (a) oscillations don't take place; (b) damped oscillations take place; (c) undamped oscillations take place.
11. One of the earliest electron tube oscillator circuits is...
    (a) a tickler feedback oscillator; (b) a gas filled tube oscillator; (c) a transistor oscillator.
12. Capacitor $C1$ is made variable...
    (a) to damp oscillations; (b) to cease oscillations; (c) to adjust the frequency of the oscillations.
13. The bypass capacitor is placed across the battery...
    (a) to provide a low-reactance path for the alternating component of the plate current; (b) to change the frequency of the oscillations; (c) to increase the amplitude of the oscillations.
14. The combination of $R$ and $C$ in the grid circuit is called...
    (a) the feedback; (b) the grid leak; (c) the rectifier.
15. The function of the grid leak is...
    (a) to rectify the plate current; (b) to adjust the plate voltage; (c) to furnish a self-adjusting bias.
16. Regenerative or positive feedback takes place when...
    (a) the voltage feedback is in phase with the voltage in the grid circuit; (b) the voltage feedback is not in phase with the voltage in the grid circuit; (c) the voltage is not fed back.
17. The plate current flowing through the tube and through the external circuit...

(a) sets up an electrostatic field; (b) reduces the resistance of the plate tank; (c) sets up an expanding magnetic field around the coil *L*.

18. As the magnetic field about coil *L* stops expanding, the voltage induced in *L*1...

(a) does not drop; (b) begins to drop; (c) does not reach zero instantly.

19. As the plate current decreases, the field about *L*...

(a) starts contracting and induces a negative voltage in *L*1; (b) does not induce any voltage in *L*1; (c) induces positive charges on *C*1.

20. As the negative charge on the grid increases, the plate current...

(a) drops until it is cut off; (b) does not drop to zero; (c) is not cut off.

*(See keys to the text on p. 149.)*

**I.** *Make up a plan on the texts from Section VIII.*

**II.** *Write an account of basic principles of operating oscillators.*

## SECTION NINE

### RECTIFIERS

1. Most power sources supply alternating current because it is easily generated and transmitted over long lines. Electron tubes, on the other hand, require direct current supply for all their electrodes, except the filaments, which may be heated either by ac or dc. The most convenient way to change alternating to direct current is by means of a rectifier.

2. A rectifier is capable of changing alternating current into a pulsating form of direct current; to obtain smooth dc power additional filter circuits are required. A complete power supply also contains a voltage divider for providing dc at various desired electrode potentials and sometimes a voltage regulator to keep the dc output voltage at a relatively constant value.

3. Rectifiers change ac into pulsating dc by eliminating the negative half-cycles or alternations of the ac voltage. Thus, only a series of sinewave pulsations of positive polarity remains. An ideal rectifier may be thought of as a switch that closes a load circuit whenever the alternating current

is positive, and opens the circuit whenever the alternating current is of negative polarity.

4. Such a switch would have in effect zero resistance when the circuit is closed during positive ac half-cycles, and infinite resistance for the time when the circuit is open during negative half-cycles. Practical rectifiers do not attain this goal, but come close to it. The resistance during the nonconducting interval called forward resistance is never zero or even constant.

5. In any case, all rectifiers must provide a substantially one-way path for electric current; that is, conduction must take place primarily in one direction only. This is called unilateral conduction, or a unidirectional characteristic. You will remember that diode tubes have such a unidirectional characteristic.

6. A diode is any electronic device consisting of two elements, one being an electron emitter or cathode, the other an electron collector or anode. Since electrons in a diode can flow in one direction only, from emitter to collector (or cathode to plate), the diode provides the unilateral conduction necessary for rectification.

7. Diodes come in many forms. They may be electron tubes of the vacuum type, crystals or semiconductors made of germanium or silicon. The last ones have the additional advantage that no filament supply is required, since no filaments are present. The latter is one of the main reasons that selenium rectifiers and crystal diodes have become increasingly popular in television and radio receivers.

8. Since a diode will permit current to flow only during the positive half-cycle of the applied ac voltage, a single diode is known as a half-wave rectifier. A half-wave rectifier circuit with its output waveforms is shown in Fig. 20.

9. The ac supply voltage is applied through a

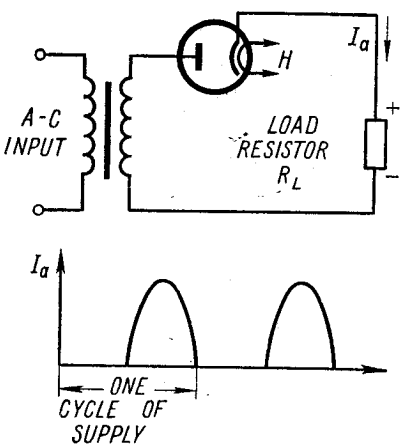


Fig. 20. Half-wave rectifier and output waveform

power transformer in series with the diode tube and load resistance, $R_L$. Plate current $I_a$ flows through the tube every other half-cycle, during positive alternations of the input voltage; it is blocked during the negative half-cycles. The current consequently flows through the load always in the same direction so as to make the cathode-connected end of $R_L$ positive.

10. Although unidirectional, the current is not direct because of its continuous changes in amplitude, or pulsations. It can be shown mathematically that these pulsations contain both a dc component and an alternating component, known as ripple. The current can be converted into a steady dc by filtering out the ac ripple with a suitable smoothing filter, as we shall see later on.

11. It is evident from Fig. 20 that during the time the plate current flows, its instantaneous amplitude follows exactly the changes in the applied voltage. The shape of the plate-current waveform as illustrated in Fig. 20 therefore, is an exact replica on the ac input voltage waveform during positive half-cycles.

12. The plate current flowing through the load resistance develops a dc output voltage, whose waveform is exactly the same as that of the plate current and is also represented by Fig. 20. But since only the positive half-cycles of the input voltage are reproduced, one-half of the input voltage is in effect lost.

13. The efficiency of the half-wave rectifier is therefore low and is used only for applications requiring a small current drain. Another disadvantage of the half-wave rectifier is that the pulsations of the output current and voltage are at the same frequency as the ac power line. Elaborate filter circuits are required to eliminate this low-frequency ripple (usually 50 cycles) and produce smooth direct current.

4000

## FULL-WAVE RECTIFIERS

1. By employing two diode half-wave rectifiers in a so-called full-wave rectifier circuit, plate current can be made to flow during the full cycle of the ac supply voltage. As evident from Fig. 21, the two diodes alternately supply rectified current to the load during both halves of the ac input voltage, and always in the same direction.

2. Note in Fig. 21 that the cathodes of the two rectifier

tubes are tied together and the common point is connected to one side of the load resistor, $R_L$. The other end of $R_L$ is connected to the center tap of the secondary winding of the power transformer.

3. Since each tube is connected between one end of the transformer winding and the centre tap, only one-half of the transformer secondary voltage appears between the plate and cathode of each diode. This means that the transformer secondary winding must supply a total voltage that is twice the value of the plate voltage required for each tube. To provide sufficient plate and output voltage, therefore, the transformer usually has a considerable step-up ratio between the primary and secondary winding.

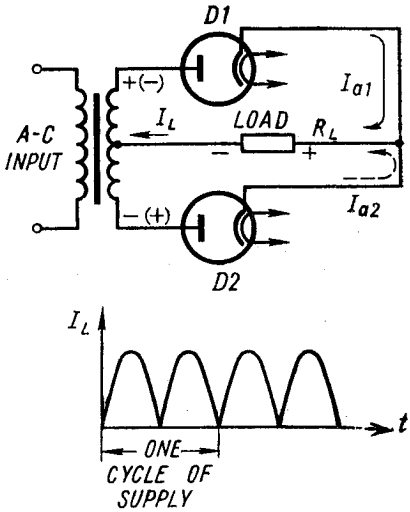


Fig. 21. Full-wave rectifier and output waveform

4. When an ac voltage is applied to the primary winding of the transformer, a voltage of the same shape, but enlarged in amplitude by the step-up ratio, appears across the secondary winding, as illustrated in Fig. 21 This secondary voltage is split in half, one-half appearing across diode 1 in series with the load $R_L$, the other half appearing across diode 2 in series with the load.

5. Assume that the polarities are such that the top of the transformer secondary winding is initially positive during the first half-cycle of the ac input voltage. The plate of diode 1, therefore, is positive with respect to the cathode, and a plate current $I_{a1}$, flows from the plate to the cathode of diode 1 through the top-half of the transformer secondary and through the load $R_L$.

6. The direction of this current, indicated by the solid arrows in Fig. 21, is such as to make the cathode-end of the load positive. The current $I_{a1}$ develops a voltage across the load, which reproduces the first half-cycle of the ac input voltage. During this first ac half-cycle the bottom of the trans-

former secondary winding is negative with respect to the centre tap and, hence, the plate of diode 2 is negative. No plate current can flow through diode 2.

7. During the second half-cycle of the ac input voltage the polarities reverse, making the top of the transformer secondary winding negative with respect to the centre tap. Hence, the plate of diode 1 is negative in respect to its cathode and no plate current flows.

8. During this same half-cycle, however, the bottom of the secondary winding is positive and thus the plate of diode 2 is positive with respect to its cathode. Consequently, a plate current $I_{a2}$ flows from the plate to the cathode of diode 2, through the bottom half of the transformer secondary and through the load, $R_L$.

9. As indicated by the solid arrows, the current flows through the load in the same direction as the previous half-cycle so that rectification is obtained. The current $I_{a2}$ flowing across the load develops an output voltage, which reproduces the second half-cycle of the ac input voltage. Thus, two positive half-cycles appear across the load during one ac cycle of the supply voltage, as is illustrated by the output waveform in Fig. 21.

10. During successive half-cycles of the ac input voltage, diodes 1 and 2 will continue to conduct alternately, each permitting current to flow during one half-cycle whenever its plate is positive with respect to the cathode. The resulting output current is a series of unidirectional pulses, as shown in Fig. 21. Since there are two output pulses for each complete cycle of the ac input voltage, the output frequency is twice that of the ac supply frequency.

11. With the ripple frequency being twice the ac supply frequency and the current much less discontinuous than that of the half-wave rectifier, the pulsations are easily smoothed out by a suitable filter circuit. Furthermore, inasmuch as both halves of the ac input cycle are rectified, the efficiency of the full-wave rectifier is far better than that of the half-wave type. In either of the two considered rectifier circuits, the vacuum diodes may be replaced by semiconductor rectifiers.

3800

## FULL-WAVE BRIDGE RECTIFIERS

1. The need for a centre-tapped power transformer is eliminated by the bridge rectifier circuit, in which four diodes

are used. The ac input to the bridge circuit is applied to diagonally opposite corners of the network, while the output to the load is taken from the remaining two corners. The circuit is a full-wave type because both halves of the ac input cycle are utilized.

2. Assume as before that the top of the transformer secondary winding is initially positive during the first half-cycle of the ac supply voltage. You may consider the transformer secondary voltage during this half-cycle to be applied across a series circuit, consisting of diode 1, the load resistor, and diode 2.

3. Since the plate of diode 1 is at maximum potential and the plate of diode 2 at maximum positive potential, an electric current flows through diode 1, the load resistor, diode 2, and the transformer secondary, in the direction indicated by the solid arrows.

4. During this first half-cycle the plates of diodes 3 and 4 are more negative than their cathodes and, hence, these diodes do not conduct. This is indicated by the positive half-cycles for diodes 3 and 4, in Fig. 22. Thus, the first half-cycle is reproduced by the conducting diodes 1 and 2 and across the load resistor, as illustrated by the solid waveforms in Fig. 22.

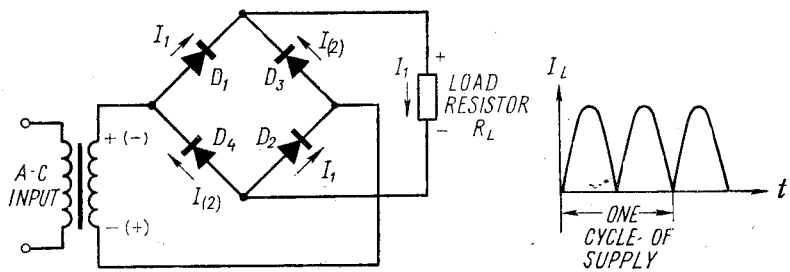


Fig. 22. Full-wave bridge rectifier circuit

5. One half-cycle later the top of the transformer secondary is negative and the bottom is positive, so that diodes 1 and 2 cannot conduct. This is indicated by the negative half-cycles for diodes 1 and 2. The plates of diodes 3 and 4 are now positive, however, with respect to their cathodes and an electric current flows through diode 3, and load resis-

tor, diode 4, and the transformer secondary, in the direction indicated by the arrows.

6. Thus, the second half-cycle of the ac supply voltage is reproduced by conducting diodes 3 and 4 and also across the oad resistor, as shown by the solid waveforms in Fig. 22. Note that the current pulses flow through the load resistor in the same direction during both ac half cycles, each pulse flowing from the plate junction of diodes 1 and 3 through the load resistor to the cathode junction of diodes 2 and 4.

7. This makes the plate-end of the load resistor negative and the cathode-end positive, since electrons flow from minus to plus. The current pulses are, therefore, unidirectional and their ripple frequency is twice that of the ac supply frequency, just as for the conventional full-wave rectifier.

8. One advantage of the bridge rectifier over the conventional full-wave rectifier is that the bridge circuit produces a voltage output nearly twice that of the conventional circuit for a given power transformer This is so because in the bridge circuit the full voltage of the transformer secondary winding is applied across two conducting diodes during each half-cycle, in contrast to the circuit of Fig. 21 where the secondary voltage is split in two.

9. The bridge circuit, however, has the disadvantage of requiring four devices which makes for uneconomical operation. The described circuit may be built up by using vacuum tubes.

2600

## Test

*Finish each sentence choosing one of the three variants (a), (b) or (c) based on the texts from Section IX.*

1. Most power sources supply...
   (a) direct current; (b) alternating current; (c) pulsating current.
2. Electron tubes for their electrodes except the filaments require...
   (a) alternating current supply; (b) varying voltage; (c) direct current supply.
3. The most convenient way to change alternating current to direct current is by means of...
   (a) an oscillator; (b) a rectifier; (c) a transformer.
4. The main elements in all dc power supplies are...

(a) rectifiers and filters; (b) batteries; (c) feedback circuits.

5. Rectifiers change ac into pulsating dc by...
   (a) amplifying the negative half-cycles of ac voltage; (b) generating dc current; (c) eliminating the negative half-cycle of the ac voltage.
6. An ideal rectifier acts like a switch that...
   (a) closes a load circuit during the negative ac half-cycles and opens the circuit during the positive ac half-cycles; (b) closes a load circuit during the positive ac half-cycles and opens the circuit during the negative ac half-cycles; (c) closes a load circuit during the negative and positive ac half-cycles.
7. All rectifiers must provide...
   (a) a one-way path for electrical current; (b) a two-way path for electrical current; (c) a three-way path for electrical current.
8. Diodes provide...
   (a) a unilateral conduction; (b) the conduction in the both sides; (c) no conduction.
9. Diodes may come in the form of...
   (a) evacuated electron tubes or semiconductors; (b) capacitor or inductance; (c) cathode-ray tubes.
10. Vacuum diodes do not have...
    (a) control grids; (b) filaments; (c) highly evacuated envelopes.
11. A single diode is called...
    (a) a full-wave rectifier; (b) a full-wave bridge rectifier; (c) a half-wave rectifier.
12. A half-way rectifier...
    (a) permits plate current flow every other half-cycle; (b) does not permit plate current flow every other half-cycle; (c) permits plate current flow only every other half-cycle during negative alternations of the ac input voltage.
13. A half-wave rectifier has...
    (a) an ac output voltage; (b) a large ac ripple voltage at the same frequency as the ac power line; (c) a large ac ripple voltage at the two-fold frequency as the ac power line.
14. A full-wave rectifier...
    (a) rectifies only one half of the ac input cycle; (b) amplifies ac input voltage; (c) rectifies both halves of the ac input cycle.

15. The conventional full-wave rectifier requires...
(a) a plate-to-plate voltage twice the value of the plate voltage for each diode; (b) a plate-to-plate voltage equal the value of the plate voltage for each diode; (c) a plate-to-plate voltage less than the value of the plate voltage for each diode.
16. A full-wave bridge rectifier uses...
(a) three diodes; (b) four diodes; (c) two diodes.
17. A full-wave bridge rectifier produces...
(a) no voltage output; (b) a voltage output nearly twice that of the conventional full-wave circuit; (c) a voltage output nearly equal that of the conventional full-wave circuit.

*(See keys to the test on p. 149.)*

**I.** *Make up a plan on the texts from Section IX.*

**II.** *Write an account of basic principles of operating rectifiers.*

*Translate into Russian using a dictionary.*

## FILTER CIRCUITS

1. Although the rectifier circuits we have discussed deliver an output voltage that always has the same polarity, this voltage is not suitable as dc supply because of the pulsations in amplitude, or ripple, of the output voltage. These pulsations must be smoothed out before the output voltage can be applied to the electron tubes or transistors. The required smoothing action is obtained by filter networks, consisting of choke coils and capacitors.

2. The filtering action of coils and capacitors depends on basic electrical principles. A capacitor opposes any change in the voltage applied across its terminals by storing up energy in an electrostatic field whenever the voltage tends to rise and converting this stored energy back into voltage or current flow whenever the voltage across its terminals tends to fall.

3. An inductor coil or choke, for short opposes any change in the magnitude of the current flowing through it by storing up energy in a magnetic field when the current through it tends to increase; and by taking energy away from this field to maintain the current flow when the current through the inductor tends to decrease.

4. Practical filter circuits are derived by combining the voltage stabilizing action of shunt capacitors with the cur-

rent smoothing action of series choke coils. If the first component of the filter is a shunt capacitor connected across the rectifier, a capacitor-input filter results; if the first component of the filter consists of a choke coil connected in series with rectifier output, a choke-input filter results.

5. A typical choke-input filter is illustrated in Fig. 23.

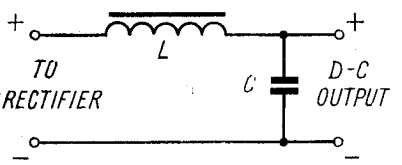


Fig. 23. Choke-input filter

The choke coil $L$ at the input of the filter readily passes the direct current from the rectifier, but opposes the ac pulsations. Any fluctuations in the current that remain after it passes through the choke are largely bypassed around the load by the shunt capacitor.

6. The action of the capacitor-input filter, illustrated in Fig. 24, is slightly different from the choke-input filter. Here

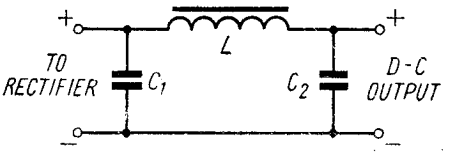


Fig. 24. Capacitor-input filter

the rectifier output voltage first charges the capacitor to the peak value of the pulsations. The capacitor tends to hold this charge between successive pulses, though discharging slowly through the choke and load.

7. As a result, the filter output voltage drops off slightly between successive pulses, but remains substantially near the peak value. The output voltage of a capacitor-input filter is therefore higher than that of a choke-input for the same ac input voltage.

8. The remaining fluctuations of the rectifier output current are opposed by the series choke and bypassed to ground by the output capacitor, $C2$. A small ac ripple remains which

may be further reduced by adding additional, identical filter sections in series.

2400

## SECTION TEN

### INTEGRATED CIRCUITS

1. The term "integrated circuit" (IC) is used to describe a group of electronic elements connected together by a variety of circuit assembly techniques[1] to perform a given electronic function. The IC technique enables many electronic compo-

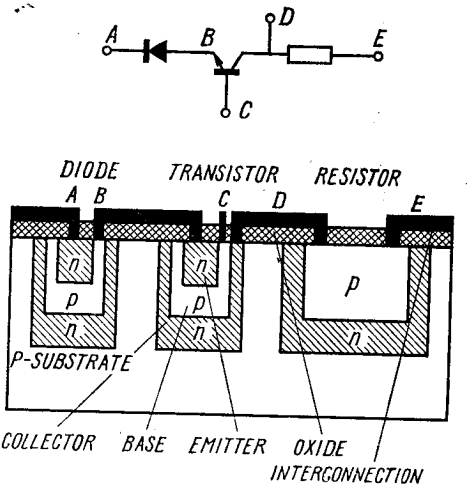


Fig. 25. Cross-section display of portion of typical monolithic IC containing diode, $n-p-n$ transistor and resistor

nents to be manufactured simultaneously, and large quantities of complex circuit can be produced in parallel. An IC containing 50 to 100 transistors and other circuit elements can fit on the head of a pin.[2]

2. There are two basic processing techniques used in the fabrication of IC devices. The semiconductor technique, which is an extension of transistor technology diffuses impurities into a block of silicon to form active (transistors and

diodes) and passive (resistors, capacitors and inductors) elements of the monolithic IC. The film technique deposits material on a common substrate to form passive and active components.

3. We shall discuss here only the first mode of fabrication, for nearly all the IC devices available on the market today are made on the basis of this technique.

4. The fabrication of monolithic devices is dependent upon the ability to selectively define and produce active and passive region in the chip. A cross-sectional view of a typical monolithic chip and the circuit it represents are shown in Fig. 25. This illustration shows the common four-layer epitaxial structure in use and how the elements are electrically isolated with reverse-biased junctions.[3]

5. The basic processing steps for producing the four-layer epitaxial IC structure are illustrated sequentially in Fig. 26. The process combines a number of photoresist and diffusion steps in conjunction with the characteristic property of silicon oxide to resist diffusion.

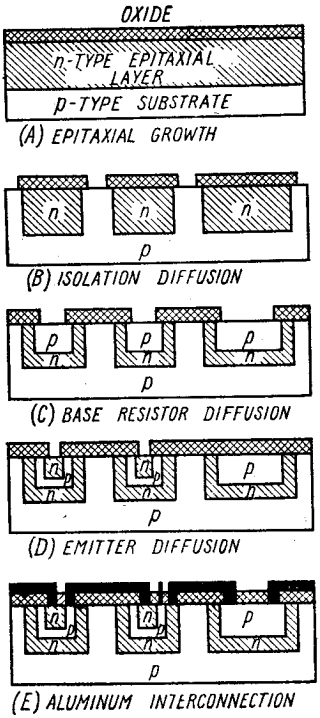


Fig. 26. Processing steps used to fabricate the circuit in Fig. 25

6. The processing of the IC begins with the growth of an *n*-type epitaxial layer on top of a *p*-type substrate (A). In this technique all elements are formed in the epitaxial layer. During growth of the epitaxial layer a protective layer of silicon oxide is formed on top of the device. This oxide is essentially impervious to the diffusion of impurities.

7. By selectively opening windows in the oxide, impurities can be introduced to selected areas of the chip to form essential parts of the circuit. After opening up windows in the oxide, the next step is the formation of isolated islands in the *n*-type region. This is done by diffusing a heavy concentration of *p*-type impurities through the epitaxial layer until the *p*-type substrate is encountered (B).

8. Another oxide layer is now grown and windows opened to permit formation of the transistor base and the resistor with a *p*-type diffusion (C). The next step is the removal of a portion of the regrown oxide to permit the *n*-type emitter region to be formed (D). A final oxide layer is then opened up to allow interconnections to be made between elements. A deposition of aluminium (E) to form the interconnection pattern completes the basic device fabrication.

9. Because of the relatively small size the transistors and diodes are used so extensively on monolithic IC chip. Resistors and capacitors require large amount of chip area, and area on a chip is quite expensive. It should be noted that present-day ICs are still primarily small-signal, low-power devices. They have the following performance characteristics, the frequency spectrum from dc to 250 Mcps, power levels up to 2 watts, and voltage and current levels up to 50 volts and 1 A, respectively.

2300

## Commentary

1. by a variety of circuit assembly techniques — посредством ряда способов сборки цепей
2. can fit on the head of a pin — могут разместиться на булавочной головке
3. with reverse-biased junctions — с помощью обратно смещенных переходов

## Test

*Finish each sentence choosing one of the three variants (a), (b) or (c) based on the texts from Section X:*

1. The term IC means...
   (a) a new method of signal amplification; (b) transforming electrical energy; (c) manufacturing electronic circuits.
2. The two basic techniques used in the fabrication of IC devices are...
   (a) the semiconductor and vacuum technique; (b) the semiconductor and film technique; (c) the film and vacuum technique.
3. The active elements in IC are...
   (a) diodes and transistors; (b) transistors and capacitors; (c) capacitors and resistors.

4. The passive elements in IC are...

(a) transistors and resistors; (b) capacitors and resistors; (c) diodes and capacitors.

5. To form active and passive elements the semiconductor technique...

(a) deposits material on the surface of the block of silicon; (b) diffuses impurities into the block silicon; (c) takes away material from some places of the surface of the block silicon.

6. To form elements of electronic circuit film technique...

(a) deposits material on a common substrate; (b) diffuses impurities into a common substrate; (c) heats a common substrate to a high temperature.

7. IC circuit illustrated in Fig. 25 comprises...

(a) a condenser, inductance and a transistor; (b) a transistor, a diode and resistance; (c) a diode, a transistor and a condenser.

8. The process of fabricating IC by semiconductor technique combines a number of...

(a) heating and cooling steps; (b) testing and control procedure; (c) photoresist and diffusion steps.

9. In the manufacture of monolithic IC all the elements are formed...

(a) in the high vacuum envelope; (b) each separately and only then they are integrated; (c) in the epitaxial layer.

10. The layer of silicon oxide which is formed on the top of the device...

(a) is a protective layer; (b) serves for electrical connection of separate components of circuit; (c) serves for circuit protecting from light radiation.

11. By opening windows in the oxide, impurities can be introduced to selected areas of the chip to form...

(a) active and passive parts of the circuit; (b) only passive parts of the circuit; (c) only active parts of the circuit.

12. A deposition of aluminium forms...

(a) *p-n-p* and *n-p-n* transistors of IC; (b) resistors and a capacitor of IC; (c) interconnection patterns of IC.

13. The transistors and diodes are used extensively on monolithic IC because of...

(a) their low reliability; (b) the relatively small size; (c) the simple technique of manufacturing.

14. It is required a large amount of chip area for...

(a) resistors and capacitors; (b) semiconductor triodes and diodes; (c) interconnections between elements.

15. Present-day ICs are primarily...

(a) powerful amplifying devices; (b) high voltage and low current devices; (c) small-signal and low-power devices.

*(See keys to the test on p. 149.)*

**I.** *Make up a plan on the texts from Section X.*

**II.** *Write an account of basic methods of producing integrated circuits.*

# Supplement

## Word Combinations and Expressions

**a lot of** много, множество, масса
**a number of** ряд, несколько
**a series of** (целый) ряд, несколько
**according to** согласно
**and so on** и т.д.
**along with** вместе с, наряду
**as a consequence** как следствие
**as against** по сравнению
**as a matter of fact** в действительности
**as a result** в результате
**as compared to** по сравнению с
**as follows** следующим образом, как ниже следует
**as for** что касается
**as if** как если бы, как будто бы
**as in the case** как в случае
**as long as** пока
**as mentioned above** как выше упоминалось
**as soon as** как только
**as to** что касается, относительно
**as well** также
**as well as** (а) также (и), так же как
**at all** вообще
**at any rate** во всяком случае, по крайней мере
**at last** наконец, в конце концов
**at least** по крайней мере
**at once** немедленно, сразу
**at times** временами
**bear in mind** иметь в виду, помнить
**because of** из-за, благодаря
**both ... and** и ... и; как ... так и
**be due to** обусловливаться, объясняться, являться результатом
**by all means** во всяком случае
**by far** гораздо, значительно, намного
**by means of** посредством, при помощи
**by no means** никоим образом
**but for** если бы не
**by the way** между прочим
**compared to** по сравнению с
**contrary to** в противоположность, вопреки
**depending on** в зависимости от
**due to** ввиду, вследствие, из-за
**each other** друг друга
**either ... or** или ... или
**even though** даже; хотя (бы)
**ever since** с того времени, с тех пор как
**except for** за исключением
**except that** за исключением (того, что)
**first of all** во-первых, прежде всего
**for example** } например
**for instance** }
**for one thing** во-первых, прежде всего
**for short** короче, для краткости
**for the purpose of** в целях, с целью
**for this reason** по этой причине
**if any** если вообще (такие имеются), если только
**if it were not for** если бы не
**if that is the case** если так
**in accordance with** в соответствии с, согласно
**in addition (to)** вдобавок, кроме того, к тому же

**in all** в общей сложности
**in all respects** во всех отношениях
**in any case** во всяком случае
**in as much as** поскольку; ввиду того, что
**in case** в случае
**in conjunction with** в связи с, вместе
**in connection with** вместе с, в связи с
**in consequence (of)** вследствие, в результате
**in contrast** в противоположность
**in comparison with** по сравнению с
**in effect** в действительности, действительно, фактически
**in general** в общем, вообще
**in fact** в действительности, в самом деле, фактически
**in its turn** в свою очередь
**in order that** для того, чтобы
**in order to** для того, чтобы
**in other words** другими словами
**in question** о котором идет речь, рассматриваемый
**in short** короче (говоря)
**in spite of** несмотря на
**in the course of** в течение
**in this manner** таким образом, таким способом
**in this respect** в этом отношении
**in so far** поскольку; так как
**instead of** вместо (того, чтобы)
**in turn** в свою очередь, поочередно
**in view of** ввиду
**it follows that** отсюда следует
**just as** как, когда
**keep in mind** иметь в виду
**later on** позднее
**lots of** масса, много, множество
**most of all** больше всего; в особенности
**no longer** больше не
**no matter** неважно, безразлично, независимо от
**of course** конечно
**on account of** вследствие, из-за
**on the one hand** с одной стороны
**on the contrary** наоборот
**on the other hand** с другой стороны
**other than** иначе
**owing to** благодаря, вследствие
**rather than** а не
**regardless of** не взирая на
**result in** приводить к, давать в результате
**result from** являться результатом
**similar to** аналогично
**since then** с тех пор, с того времени
**so as to** так, чтобы
**so far** до сих пор; пока
**so far as** поскольку, что касается, насколько
**so long as** пока
**such as** как, например
**take advantage of** воспользоваться
**take care of** заботиться
**take part** принимать участие, участвовать
**take place** иметь место, происходить, случаться
**thanks to** благодаря
**that is** то есть
**that is why** вот почему
**the ... the** чем ... тем
**the former** первый из упомянутых выше
**the latter** последний из упомянутых выше
**thus far** пока что; до сих пор
**to some extent** до некоторой степени
**to such an extent** до такой степени
**twice as much** в два раза больше
**under any conditions** при любых условиях
**under consideration** представленный на рассмотрение, рассматриваемый
**up to** до; вплоть до
**up-to-date** новейший, современный
**were it not for** если бы не
**with reference to** относительно, что касается, ссылаясь на
**with regard to** по отношению к, относительно
**with relation to** относительно, что касается
**with respect to** по отношению к, в отношении
**worth while** стоит

## Reading Numerals

1/2 one half
1 1/2 one and a half
1/3 one third
1/4 one fourth
1/6 one sixth
1/25 one twenty-fifth
1/136 one one hundred and thirty-sixth
2/3 two thirds
3/4 three fourths
0.1 zero (0, naught) point one
0.04 zero (0, naught) point zero four
0.25 zero (0, naught) point two five
4.6 four point six
5.37 five point three seven

## Reading Mathematical Signs (Terms)

\+ plus
— minus
× *or* · multiplied by (times)
: divided by (over)
= equals (is equal to)
> greater than
< less than
( ) round brackets
[ ] square brackets
% per cent
$3^2$ three squared
$4^3$ four cubed
$5^4$ 5 fourth, 5 fourth power
$a^n$ *a n*-th, *a n*-th power
$E_C$ *E* sub *C*
$a_2$ *a* sub 2
$I_C - E_C$ *I* sub *C* minus *E* sub *C*
$x_3 + z_2$ *x* sub 3 plus *z* sub 2
$x = -\frac{c+d}{ab-1}$ *x* equals minus *c* plus *d* divided by *a* multiplied by *b* minus 1

## Abbreviations

ac — alternating current
dc — direct current
a.f. — audio frequency
C — centigrade
cm — centimeter
amp. — ampere
c.p.s. — cycles per second
CRT — cathode-ray tube
e.m.f. E.M.F. — electromotive force
etc. — *et cetera* = and so on
IC — integrated circuit
i.e. *id est* = that is
kc. — kilocycle
ma. mA — milliampere
Mcps — megacycle per second
*n-p-n* — negative-positive-negative
*p-n-p* — positive-negative-positive
sq. — square
r.f. — radio frequency
via — by way of
vs. — *versus* = against

### VOCABULARY

*a* adjective прилагательное
*adv* adverb наречие
*conj* conjunction союз
*n* noun существительное
*num* numeral числительное
*pron* pronoun местоимение
*prep* preposition предлог
*v* verb глагол

**ability** *n* способность
**abbreviate** *v* сокращать
**above** *adv* наверху, выше
**abrupt** *a* резкий
**abstract** *n* резюме , конспект
**accelerate** *v* ускорять
**acceptance** *n* принятие
**acceptor atom** атом акцепторной примеси
**accidental** *a* случайный
**accomodate** *v* приспосабливать, снабжать; давать пристанище
**accomplish** *v* совершать, выполнять
**account** *n* доклад; сообщение, отчет
**account for** *v* обьяснять; отчитываться
**accurate** *a* точный
**achieve** *v* достигать; успешно выполнять;
**acquire** *v* приобретать; достигать
**across** *adv* поперек; *prep* сквозь, через, к
**act** *v* действовать
**actually** *adv* действительно
**add** *v* прибавлять, присоединять; складывать
**adjacent** *a* смежный, примыкающий, соседний
**adjust** *v* регулировать; приспосабливать, пригонять
**adopt** *v* принимать; усваивать
**advance** *n* продвижение; успех
**advantage** *n* преимущество, выгода
**adversely** *adv* враждебно; неблагоприятно
**affect** *v* влиять; действовать
**after** *adv* потом, затем; *prep* после; *conj* после того как
**afterglow** *n* послесвечение
**again** *adv* снова, опять
**aid** *v* помогать; *n* помощь
**aim** *n* цель; намерение
**air-conditioner** *n* вентилятор
**allow** *v* позволять, разрешать
**alloy** *n* сплав; примесь
**almost** *adv* почти
**alone** *a* один, одинокий; *adv* только
**alter** изменять(ся)

**alternating** *a* переменный
**alternation** *n* перемена; половина цикла; чередование
**among** *prep* среди, между
**amount** *v* доходить (до); составлять (сумму); равняться; *n* сумма, итог
**amplification factor** коэффициент усиления
**amplifier** *n* усилитель
**amplitude** *n* амплитуда
**angle** *n* угол
**aperture** *n* отверстие; проход
**apparent** *a* очевидный; видимый
**appear** *v* показываться; появляться
**appliance** *n* приспособление; применение
**application** *n* применение
**applied science** прикладная наука
**apply** *v* применять; прилагать; прикладывать
**appreciate** *v* оценивать; ценить
**appropriate** *a* подходящий, соответствующий
**arise from** *v* **(arose, arisen)** возникать, появляться
**arrange** *v* устраивать; располагать; классифицировать
**arrive** *v* прибывать; достигать
**arrow** *n* стрелка
**artificial** *a* искусственный
**ascertain** *v* устанавливать, выяснять
**assign** *v* назначать, определять
**associate** *v* соединять
**assume** *v* допускать, предлагать, принимать на себя
**astonishing** *a* удивительный, изумительный
**attach** *v* прикреплять, прикладывать
**attain** *v* достигать
**attract** *v* притягивать
**audio** *a* звуковой
**audio frequency output voltage** выходное напряжение звуковой частоты
**available** *a* наличный; доступный
**average** *v* в среднем равняться

**avoid** *v* избегать
**axis** *n* (*pl* **axes**) ось

## B

**balance** *v* уравновешивать; *n* равновесие
**barrier** *n* барьер; запирающий слой
**base** *v* основывать; *n* база
**beam** *n* луч, пучок
**before** *prep* перед, до; *adv* раньше, уже, впереди; *conj* прежде чем
**behave** *v* поступать, вести себя
**believe** *v* верить, полагать
**bend** *v* (**bent, bent**) изгибать, сгибать
**besides** *adv, prep* кроме, кроме того
**bias** *v* смещать; *n* смещение
**bid** *v* стремиться; велеть
**bind** *v* (**bound, bound**) связывать
**bleeder resistor** делитель напряжения
**bond** *n* связь; **covalent bond** ковалентная связь
**boost** *v* усиливать, повышать
**both** *a, pron* оба, и тот и другой
**bottom** *n* дно, низ, нижняя часть
**branch** *n* отрасль
**break down** *v* (**broke, broken**) разрушаться
**bring about** *v* (**brought, brought**) осуществлять, влечь за собой
**build up** *v* (**built, built**) создавать
**bulky** *a* большой, объемистый
**bypass** *v* шунтировать, обходить; *n* шунт, байпас; **bypass capacitor** шунтирующий конденсатор

## C

**calculate** *v* вычислять; подсчитывать
**call** *v* называть
**cancel** *v* уничтожать, аннулировать
**capable** *a* способный
**capacitance** *n* емкость, емкостное сопротивление
**capacitor** *n* конденсатор, емкость; **capacitor-input filter** фильтр с емкостным входом
**capacity** *n* емкость, номинальная мощность; способность; производительность; **capacity resistance** емкостное сопротивление
**carbon** *n* углерод; угольный электрод
**care (for, about)** *v* заботиться; *n* забота, уход
**carrier** *n* носитель, переносчик *(энергии)*
**carry** *v* нести, носить; проводить
**cathode-ray tube** катодно-лучевая трубка
**cause** *v* причинять, вызывать; заставлять; *n* причина, основание; дело
**cease** *v* прекращать(ся), приостанавливать
**century** *n* столетие
**cell** *n* элемент
**change** *v* изменять
**characteristic curve** кривая характеристика
**charge** *v* заряжать; *n* заряд
**check** *v* проверять, контролировать; *n* проверка, контроль
**chip** *n* пластина
**choke** *n* дроссель
**choke-input filter** фильтр с дроссельным входом
**choose** *v* (**chose, chosen**) выбирать
**circuit** *n* цепь, контур; **closed circuit** замкнутая цепь; **monolithic circuit** твердая схема
**clamp** *v* скреплять
**clearly** *adv* ясно
**close** *a* близкий; **close to** около, почти, приблизительно
**cloud** *n* облако
**coat** *v* покрывать
**coil** *n эл.* катушка; **inductance coil** катушка индуктивности; **choke coil** дроссельная катушка
**coincide** *v* совпадать; соответствовать
**collapse** *v* рушиться
**collector** *n* коллектор
**collector-junction** коллекторный переход
**collide** *v* сталкиваться

**combat** *v* бороться против чего-л.
**commercial** *a* промышленный
**common-base amplifier** усилитель по схеме с общей базой
**common-collector-amplifier** усилитель по схеме с общим коллектором
**common-emitter-amplifier** усилитель по схеме с общим эмиттером
**communicate** *v* сообщать; сообщаться; сноситься
**communication** *n* связь
**comparison** *n* сравнение
**completely** *adv* совершенно
**complicated** *a* сложный
**compound** *n* соединение
**comprehension** *n* понимание
**comprise** *v* включать; содержать; вмещать
**compute** *v* считать, подсчитывать
**computer** *n* счетчик, компьютер
**conceive** *v* постигать; понимать
**concern** *v* интересоваться; касаться
**concerning** *adv* относительно, что касается
**condenser** *n* конденсатор
**condition** *n* условие
**conduct** *v* проводить
**conduction** *n* проводимость
**conductivity** *n* удельная проводимость; электропроводность
**conductor** *n* проводник
**configuration** *n* конфигурация; очертание; форма
**confine** *v* ограничивать
**connect** *v* соединять
**consequently** *adv* следовательно
**consider** *v* рассматривать, обсуждать
**considerably** *adv* значительно
**consist (of)** *v* состоять (из)
**constant** *n* постоянная величина; *a* постоянный
**constituent** *n* составная часть
**constitute** *v* составлять
**consume** *v* потреблять
**consumption** *n* потребление; расход
**contain** *v* содержать, вмещать
**continual** *a* беспрерывный
**continue** *v* продолжать
**continuous** *a* постоянный (*о токе*); непрерывный
**contribute** *v* содействовать, способствовать; сделать вклад (*в науку*)
**control** *v* управлять; регулировать; *n* регулирование; управление, контроль; **control grid** управляющая сетка
**conveniently** *adv* удобно
**conventional** *a* стандартный; обычный, общепринятый
**converge** *v* сходиться (*о линиях, дорогах*); приближаться
**conversely** *adv* наоборот
**conversion** *n* превращение
**convert** *v* превращать
**convey** *v* передавать
**copious** *a* обильный
**copper** *n* медь
**core** *n* сердечник
**corresponding** *a* соответствующий
**couple** *v* соединять; *n* пара
**coupling** *n* связь; **coupling capacity** конденсатор связи
**create** *v* создавать
**critical** *a* критический, решающий
**cross** *v* пересекать
**current gain** коэффициент усиления по току
**current voltage characteristic** вольтамперная характеристика
**curve** *n* кривая (линия); изгиб
**cut** *v* резать, отключать; **cut off** отсекать
**cut-off** *n* отсечка, отключение, выключение
**cut-off bias** запирающее напряжение
**cybernetics** *n* кибернетика
**cycle** *n* цикл, период

## D

**damage** *v* повреждать, портить; *n* повреждение; вред
**damped** *a* затухающий, демпфированный
**damping** *n* затухание, глушение (*сигнала*)
**data** *pl* данные (*sing.* **datum**)
**decrease** *v* уменьшать

**deficiency** *n* недостаток, отсутствие
**define** *v* определять
**deflection** *n* отклонение
**degenerative feedback** отрицательная обратная связь
**degree** *n* степень; градус
**delay** *v* задерживать; *n* задержка
**deliver** *v* доставлять; передавать
**denote** *v* обозначать
**density** *n* плотность, концентрация
**depend (up)on** *v* зависеть
**deposit** *v* осаждать
**derive** *v* происходить; производить
**describe** *v* описывать
**design** *v* проектировать; конструировать; *n* проект; конструкция, расчет
**desire** *v* желать
**detector** *n* детектор
**determine** *v* определять
**develop** *v* развивать; разрабатывать
**device** *n* приспособление; механизм; **output device** устройство для выдачи результатов
**diamond** *n* алмаз
**diffuse** *v* распространять; рассеивать
**dim** *a* тусклый; неясный
**dimensions** *n* размеры, величина
**diode** *n* диод
**direct current (dc)** постоянный ток
**directly** *adv* прямо; непосредственно
**disadvantage** *n* невыгода, ущерб; неудобство
**discharge** *v* разряжаться; *n* разряд
**discover** *v* открывать
**discriminate (against)** *v* отличать, выделять; дискриминировать; относиться по-разному
**disintegrate** *v* распадаться, разрушаться
**dislodge** *v* вытеснять; выбивать
**displace** *v* смещать; перемещать
**display** *v* выставлять, показывать; проявлять; *n* проявление, показ
**disrupt** *v* разрывать
**dissipate** *v* рассеивать
**distinguish** *v* различать; отмечать
**distort** *v* искажать; искривлять
**distribute** *v* распределять
**disturb** *v* нарушать, мешать
**diverge** *v* расходиться; отклоняться
**divider** *n* делитель, делительное устройство
**donate** *v* дарить, жертвовать
**donor** *n* донор (*полупроводник с избыточными электронами*); **"donor" atom** атом донорной примеси
**dope** *v* вводить примесь; **"doped" germanium crystal** кристалл германия с примесью
**doping** введение примеси
**dot** *n* точка
**dotted graphs** пунктирные линии
**double junction** сдвоенный переход
**drain** *n* потребление тока
**drift** *v* отклоняться; *n* сдвиг
**drive** *v* **(drove, driven)** двигать, приводить в движение; *n* передача, привод
**drop** *v* падать; спадать; *n* падение

## E

**effect** *v* совершать, выполнять; *n* действие, влияние; эффект
**efficiency** *n* эффективность; производительность; коэффициент полезного действия
**efficient** *a* действенный, эффективный
**either** *a, pron* каждый (из двух); оба; и тот и другой
**elaborate** *a* детально разработанный; сложный
**elastic** *a* упругий, гибкий; эластичный
**electron gun** электронная пушка
**electron hole pair** электронно-дырочная пара
**electron tube oscillator** электронно-ламповый генератор
**eliminate** *v* устранять; уничтожать
**emission** *n* эмиссия, испуска-

ние электронов; **field emission** холодная эмиссия
**emit** *v* испускать, выделять; излучать
**employ** *v* применять, использовать
**enable** *v* давать возможность, приспосабливать
**enclose** *v* заключать; вкладывать; огораживать
**engineering** *n* техника
**enlarge** *v* расширять, увеличивать
**enter** *v* входить
**enterprise** *n* предприятие
**entirely** *adv* всецело, совершенно
**envelope** *n* баллон, колба, трубка
**environment** *n* окружение, среда
**epitaxial** *a* эпитексильный
**equal** *v* равняться; *a* равный
**equip** *v* оборудовать
**equivalent** *a* равноценный, эквивалентный
**escape** *v* давать утечку, улетучиваться (*о газах, паре*); *n* выпуск, выход (*пара*)
**essential** *a* существенный; необходимый
**establish** *v* устанавливать; основывать
**evacuate** *v* выкачивать, высасывать, разряжать воздух
**even** *a* четный; ровный; *adv* даже
**eventually** *adv* в конце концов
**evident** *a* очевидный
**exactly** *adv* точно
**exaggerate** *v* преувеличивать
**examine** *v* исследовать; осматривать
**exceed** *v* превышать; превосходить
**excess** *n* излишек, избыток
**excessive** *a* чрезмерный
**excite** *v* возбуждать (*ток*)
**exist** *v* существовать
**expand** *v* расширять(ся); увеличивать(ся)
**expect** *v* ждать; надеяться; предполагать
**expend** *v* тратить; расходовать
**expensé** *n* трата, расход
**expensive** *a* дорогой
**explain** *v* объяснят
**explore** *v* исследовать
**expose** *v* подвергать действию
**express** *v* выражать
**expression** *n* выражение
**extend** *v* тянуться, простираться
**extensively** *adv* широко
**extent** *n* степень, размер; **to some extent** до некоторой степени
**extinction** *n* затухание, ослабление
**extract (from)** *v* вырывать; извлекать
**extremely** *adv* чрезвычайно, крайне

## F

**fabrication** *n* производство
**face** *v* стоять перед; *n* экран (*кинескопа*)
**fail** *v* не доставать; не удаваться
**fairly** *adv* довольно
**fall** *v* **(fell, fallen)** падать; **fall off** отпадать; уменьшаться
**familiar** *a* близкий; хорошо знакомый
**family** *n* (*зд.*) семейство
**feed (fed, fed)** *v* питать; *n* питание
**feedback** *n* обратная связь; **feedback factor** коэффициент обратной связи; **feedback loop** петля обратной связи
**filament** *n* нить накала; волосок
**fill** *v* наполнять
**film** *n* пленка
**filter** *n* фильтр
**final** *a* конечный
**finally** *adv* наконец
**find out** *v* **(found, found)** узнавать, открывать
**fine** *a* тонкий; **fine control** точное управление
**first** *adv* сначала, сперва
**fit** *v* **(in)** пригонять; **(out)** снабжать
**fix** *v* прикреплять

**fixed** *a* постоянный; неподвижный; закрепленный
**flatten** *v* выравнивать(ся)
**flexible** *a* гибкий
**fluctuation** *n* колебание, качание
**fluorescent screen** флуоресцирующий экран
**focus** *v* собираться в фокус; *n* фокус
**focus coil** фокусирующая катушка
**focusing** *n* фокусирование
**follow** *v* следовать, идти за; преследовать
**follower** *n* повторитель
**for** *prep* за, для, в течение; *conj* так как, ибо
**force** *v* заставлять; форсировать; *n* сила
**forward bias** прямое смещение
**forward resistance** прямое сопротивление
**fraction** *n* дробь; частица, доля
**frequently** *adv* часто
**full-wave bridge rectifier** выпрямитель по мостовой схеме
**full-wave type rectifier** двухполупериодный выпрямитель
**function** *v* функционировать, действовать; *n* функция
**funnel** *n* воронка; *a* воронкообразный
**further** *adv* дальше, далее
**furthermore** *adv* кроме того, к тому же
**fuse** *v* плавиться, сплавляться; *n* плавкий предохранитель
**fused junction** переход, полученный перекристаллизацией
**fused p—n junction** сплавной *p—n*-переход

## G

**gadget** *n* приспособление
**gain** *v* приобретать; достигать; *n* увеличение; коэффициент усиления
**gather** *v* собирать
**generally** *adv* вообще, обычно
**generate** *v* генерировать; вырабатывать, производить
**germanium** *n* германий
**give off** *v* (**gave, given**) выделять
**give rise** вызывать
**give up** отдавать
**glow** *v* сверкать; *n* свечение; накал
**goal** *n* цель
**govern** *v* управлять; регулировать
**graph** *n* диаграмма
**grid-leak resistor** резистор сеточной утечки
**grid-to-cathode voltage** напряжение сетка-катод
**grid voltage supply** подача напряжения на сетку
**ground** *n* заземление, земля
**grow** *v* (**grew, grown**) расти, вырастать из, перерастать
**guide** *v* управлять, руководить

## H

**half** *n* половина; **half-cycle** полупериод
**half-wave rectifier** одно-полупериодный выпрямитель
**handle** *v* управлять; обращаться с
**heat** *v* нагревать(ся); *n* теплота, накал, нагрев
**hence** *adv* отсюда, следовательно
**highly** *adv* очень
**hinder** *v* мешать
**hold** *v* (**held, held**) держать, удерживать
**hole** *n* дырка
**hollow** *a* полый, пустой
**hook up** *v* (*зд.*) соединять
**hot-cathode tube** лампа с подогревным катодом
**however** *adv* однако, тем не менее
**humanity** *n* человечество

## I

**identify** *v* отождествлять
**image** *v* изображать, создавать изображение; *n* изображение
**immediately** *adv* немедленно
**impact** *n* удар, толчок, импульс
**impart (to)** *v* сообщать: придавать

**impedance** *n* полное сопротивление
**impedance matching** согласование или подгонка полных сопротивлений
**impede** *v* препятствовать; задерживать, мешать
**impervious** *a* непроницаемый
**impinge** *v* ударяться, падать
**imply** *v* подразумевать; заключать в себе
**impress** *v* усиливать
**impurity** *n* примесь
**incident** *a* случайный; *n* случай; **incident light** падающий свет
**include** *v* включать
**increase** *v* возрастать, увеличивать(ся)
**increment** *n* возрастание, приращение
**indeed** *adv* действительно
**indicate** *v* указывать, показывать, означать
**indispensable** *a* необходимый
**induce** *v* индуктировать, возбуждать ток
**inductance** *n* индуктивность; коэффициент настройки; **inductance coil** катушка индуктивности
**inductive reactance** индуктивное сопротивление
**inductor** *n* катушка индуктивности
**infinite** *a* бесконечный, безграничный
**influence (on, upon)** *v* влиять; *n* влияние
**initial** *a* первоначальный
**inject** *v* вводить, впускать, вспрыскивать
**input** *n* вход; *a* входной; **input transformer** входной трансформатор
**insert** *v* вставлять; (*эл.*) включать
**inside** *a* внутренний; *adv* внутри
**instant** *n* момент; *a* мгновенный
**instantaneous** *a* мгновенный
**insulate** *v* изолировать
**integrated circuit** интегральная цепь
**intensity** *n* напряженность, интенсивность
**intentional** *a* намеренный
**interfere** *v* вмешиваться, мешать
**intermediate** *a* промежуточный
**internal** *a* внутренний
**intersect** *v* пересекать
**introduce** *v* вводить
**invent** *v* изобретать
**inverse** *a* обратный
**investigate** *v* исследовать
**involve** *v* включать (в себя); вызывать
**irrespective** *a* независимый, безотносительный

## J

**Job** *n* работа
**Join** *v* соединять(ся); присоединять(ся)
**junction** *n* переход; соединение
**junction tetrode transistor** плоскостный полупроводниковый тетрод
**junction triode transistor** плоскостный полупроводниковый триод
**just as** как, когда

## K

**key** *n* ключ
**knock out** *v* выбивать

## L

**lack** *v* испытывать недостаток; *n* недостаток
**lag (behind)** *v* отставать
**layer** *n* слой, пласт
**leak** *v* давать течь; просачиваться; *n* утечка
**leakage** *n* утечка
**let** *v* **(let, let)** позволять; пускать; давать
**level** *n* уровень
**liberate** *v* освобождать
**lie** *v* **(lay, lain)** лежать; находиться, заключаться
**line** *n* линия, строка
**linear** *a* линейный
**literally** *adv* буквально
**load** *v* нагружать; *n* нагрузка; **load resistance** нагрузочное сопротивление; **load resistor** сопротивление нагрузки
**locate** *v* располагать
**loop** *n* петля; контур

**loose** *a* свободный; просторный
**lose** *v* **(lost, lost)** терять
**loss** *n* потеря
**luminous** *a* светящийся; светлый

## M

**magnitude** *n* величина; значительность, важность
**main** *a* главный
**mainly** *adv* главным образом
**majority** *n* большинство; **majority carrier** основной носитель
**maintain** *v* поддерживать, содержать
**make up** *v* **(made, made)** составлять
**management** *n* управление
**mankind** *n* человечество
**manual** *n* руководство; справочник; *a* ручной
**manufacture** *v* производить; *n* производство
**mark** *v* отмечать
**market** *n* рынок
**match** *v* сочетать; подбирать под пару
**matter** *n* материя; дело
**mean** *v* **(meant, meant)** значить, иметь в виду
**means** *n* средство
**measure** *v* измерять; *n* мера
**medium** *n* среда; *a* средний; умеренный
**melt** *v* плавить(ся)
**mention** *v* упоминать; *n* упоминание
**meter** *n* счетчик; измерительный прибор
**minority** *n* меньшинство; **minority carrier** неосновной носитель заряда
**mixture** *n* смешивание; смесь
**mobile** *a* подвижной
**mode** *n* режим
**moderate** *a* умеренный; средний
**modern** *a* современный
**modify** *v* видоизменять
**monitor** *v* проверять, контролировать
**moreover** *adv* кроме того
**motion** *n* движение, ход
**mount** *v* устанавливать, монтировать
**movement** *n* движение
**multiple** *n* кратное число; *a* многократный, многочисленный
**multiply** *v* увеличивать(ся); умножать
**mutual** *a* взаимный, обоюдный

## N

**namely** *adv* а именно, то есть
**nearly** *adv* почти, около, приблизительно
**necessitate** *v* делать необходимым, вынуждать
**neck** *n* горловина
**negative** *a* отрицательный
**negative dc bias** отрицательное смещение по постоянному току
**neglect** *v* пренебрегать
**neighbour** *n* сосед; *a* соседний
**net** *a* чистый, полезный
**network** *n* сеть, четырехполюсник
**neutralize** *v* нейтрализовать
**nichrome** *n* нихром
**notation** *n* изображение
**note** *v* замечать
**notice** *v* замечать; отмечать
**n-region** область *n*-проводимости
**n-type germanium** германий *n*-типа
**n-type material** материал с проводимостью *n*-типа
**nucleus** (*pl* **nuclei**) *n* ядро
**nullify** *v* аннулировать; делать недействительным
**numerous** *a* многочисленный

## O

**obey** *v* повиноваться, подчиняться
**obtain** *v* получать
**obvious** *a* очевидный, явный
**occasionally** *adv* время от времени; случайно; изредка
**occur** *v* попадаться, встречаться, случаться
**offer** *v* предлагать; **offer resistance** оказывать сопротивление
**opening** *n* отверстие
**operate** *v* действовать, работать

**oppose** *v* оказывать сопротивление, сопротивляться
**opposite** *a* обратный; противоположный
**orbit** *v* огибать; *n* орбита
**order** *n* порядок
**ordinary** *a* обычный
**origin** *n* происхождение; начало; источник
**oscillate** *v* колебаться; вибрировать
**oscillator** *n* генератор (колебаний)
**otherwise** *adv* иначе; в противном случае
**outer** *a* внешний, наружный
**outermost** *a* самый дальний от середины, от центра
**output** *n* выход; выходная мощность; к.п.д.; **output power** выходная мощность; **output resistance** выходное сопротивление; **output transformer** выходной трансформатор; **output voltage** выходное напряжение
**overcome** *v* (**overcame, overcome**) преодолеть
**overlay** *v* покрывать
**overload** *v* перегружать
**oxyde** *n* окисел

## P

**pair** *n* пара
**partial** *a* частичный, неполный
**particle** *n* частица
**particularly** *adv* особенно, чрезвычайно
**pass** *v* пропускать; передавать (*ток через цепь*)
**peak** *n* максимум (*нагрузки*)
**penetrate** *v* проникать, проходить сквозь
**pentavalent** *a* пятивалентный
**perform** *v* выполнять; совершать
**performance** *n* характеристика; работа; действие
**permeability** *n* проницаемость
**permit** *v* разрешать
**persistence** *n* (*зд.*) послесвечение
**phase shift** *n* сдвиг фазы
**phenomenon** *n* (*pl* phenomena) явление
**plant** *n* завод
**plate** *n* анод, пластинка
**plate current** анодный ток
**plate supply voltage** подача напряжения на анод
**plate-to-cathode voltage** анодное напряжение
**plot** *v* наносить; чертить; откладывать на графике
**p-material** материал с *p*-проводимостью
**p—n junction** *p—n* переход
**p—n junction diode** диод с *p—n* переходом
**p—n—p junction transistor** *p—n—p* транзистор
**point** *n* точка; пункт; вопрос; дело
**point out** *v* указывать
**poor** *a* плохой, бедный
**portion** *n* часть
**positive** *a* положительный
**possess** *v* обладать
**potential barrier** потенциальный барьер
**potential difference** разность потенциалов
**potential divider** делитель напряжения
**power gain** коэффициент усиления по мощности
**power station** электростанция
**power supply system** система питания, источник мощности
**power transformer** силовой трансформатор
**practically** *adv* фактически
**precaution** *n* предосторожность
**predominantly** *adv* преимущественно
**p-region** область с *p*-проводимостью
**present** *v* представлять
**previously** *adv* предварительно
**primary** *a* первичный; основной
**probe** *n* космическая станция
**procedure** *n* процедура; процесс
**proceed** *v* приступить, перейти к чему-л.
**processing** *n* обработка, изготовление
**produce** *v* вырабатывать; производить; вызывать, быть причиной

**product** *n* продукт; результат; (*мат.*) произведение
**profound** *a* глубокий
**proper** *a* надлежащий; правильный; подходящий
**properly** *adv* собственно; правильно; должным образом
**property** *n* свойство
**proton** *n* протон
**prove** *v* доказывать; оказываться
**provide (with)** *v* обеспечивать; снабжать; предусматривать
**provided** *conj* при условии; если только
**proximity** *n* близость
**p-type germanium** германий *p*-типа
**pull** *v* (*зд.*) вырывать; тащить, тянуть
**pulse** *n* импульс, полупериод
**purpose** *n* цель

## Q

**quality** *n* качество
**quantitative** *a* количественный
**quantity** *n* количество, величина

## R

**radar** *n* радар, радиолокатор
**radial** *a* радиальный; лучевой
**radiation** *n* излучение
**radio frequency carrier** несущая радиочастота
**radio-receiving** радиоприем
**raise** *v* поднимать; повышать
**range** *v* колебаться в пределах; *n* диапазон
**rapid** *a* быстрый, скорый
**rate** *n* скорость; темп
**rated value** номинальная величина
**rating** *n* номинальное значение
**rather** *adv* довольно, до некоторой степени; скорее, вернее
**rather than** а не
**ratio** *n* отношение, коэффициент
**ray** *n* луч
**reach** *v* достигать
**reactance** *n* реактивное сопротивление
**readily** *adv* легко
**realm** *n* область, сфера
**reason** *n* причина
**reasonable** *a* приемлемый; разумный, целесообразный
**recall** *v* вспоминать; напоминать
**receive** *v* получать, принимать
**receiver** *n* приемник
**reciprocal** *a* взаимный, эквивалентный
**recognition** *n* признание
**recover** *v* восстанавливать
**rectifier** *n* выпрямитель
**rectify** *v* выпрямлять
**reduce** *v* понижать, уменьшать
**refer** *v* относиться; ссылаться на
**regard** *v* рассматривать; считать
**regard of** независимо от, невзирая на
**regenerative feedback** положительная обратная связь
**region** *n* зона; область
**register** *n* счетчик
**reinforce** *v* укреплять
**relate** *v* иметь отношение
**related** *a* связанный; родственный
**relation** *n* зависимость, отношение
**relative** *a* относительный, сравнительный
**relatively** *adv* относительно
**relay** *v* передавать; *n* реле
**release** *v* освобождать; отпускать
**reliable** *a* надежный; прочный
**rely** *v* полагаться, доверять
**remain** *v* оставаться
**remainder** *n* оставшаяся часть
**remote** *a* отдаленный; дистанционный
**remove** *v* удалять; снимать
**repair** *v* ремонтировать, исправлять; *n* ремонт
**repel** *v* отталкивать(ся)
**replenish** *v* пополнять, дополнять
**replica** *n* копия
**represent** *v* представлять, изображать
**representation** *n* воспроизведение
**reproduce** *v* воспроизводить
**repulsion** *n* отталкивание
**require** *v* требовать
**research** *v* исследовать; *n* исследование

**residual** *a* остаточный; оставшийся
**resist** *v* сопротивляться; противостоять
**resistance** *n* электрическое сопротивление; **back resistance** обратное сопротивление
**resistance coupling** резистивная связь
**resistance network** цепь повышенного сопротивления
**resistor** *n* сопротивление
**resonant circuit** резонансный контур
**respectable** *a* (*зд.*) значительный
**respectively** *adv* соответственно
**respond** *v* реагировать, отзываться
**response** *n* реакция; ответ
**responsible** *a* ответственный
**restrain** *v* сдерживать, удерживать
**restrict** *v* ограничивать
**result from** *v* являться результатом
**result in** *v* приводить к
**retain** *v* удерживать, поддерживать; сохранять
**retard** *v* задерживать, замедлять
**retrace** *n* обратный ход развертки
**return** *v* возвращать(ся); *n* возврат; отдача; возвращение
**reserve** *v* реверсировать; менять (*направление движения тока*)
**revolution** *n* полный оборот; круговое вращение
**revolve** *v* вращаться
**rigid** *a* жесткий; неподвижный
**ripple** *n* пульсация
**rise** *v* **(rose, risen)** подниматься; *n* подъем, повышение
**roam** *v* бродить, странствовать
**rod** *n* стержень, прут
**rough** *a* грубый; приблизительный
**rugged** *a* прочный

S

**sandwich** *n* (*зд.*) слоистая структура
**saturate** *v* насыщать
**saturation value** величина насыщения
**saw-tooth** *a* пилообразный
**saw-tooth sweep generator** генератор пилообразного напряжения
**scanning** *n* развертка
**scheme** *n* план; схема
**scope** *n* сфера; размах, простор
**scores** множество
**screen** *n* экран
**seal** *v* запаивать, закупоривать
**search** *n* поиски; исследование
**secondary** *a* вторичный
**section** *n* часть, сечение, разрез; отрезок
**secure** *v* гарантировать, обеспечивать
**select** *v* избирать, выбирать
**selenium** *n* селен
**semiconductor** *n* полупроводник
**semiconductor diode junction** полупроводниковый диодный переход
**sensitive** *a* чувствительный
**separate** *v* отделять(ся), разделять(ся)
**sequentially** *adv* последовательно
**series** *n* ряд, серия
**serve** *v* служить
**set** *v* **(set, set)** устанавливать; *n* ряд, комплект
**set up** *v* создавать, устанавливать
**several** *pron* несколько
**shape** *n* форма
**sharp** *a* острый; отчетливый; резкий
**shed** *v* **(shed, shed)** проливать (свет)
**shell** *n* оболочка
**shield** *v* экранировать; защищать; *n* экран
**shunt** *n* шунт
**sideways** *adv* в сторону, вбок
**signal voltage** напряжение сигнала
**silicate** *n* силикат
**silver** *n* серебро
**similar** *a* сходный; подобный; однородный
**simultaneously** *adv* одновременно

**since** *prep* с; *conj* так как; с тех пор как; поскольку
**size** *n* размер, величина
**smooth** *v* сглаживать; *a* ровный
**solid** *a* твердый, сплошной; *n* твердое тело
**solution** *n* раствор; решение
**somewhat** *n* некоторая часть; *adv* отчасти, до некоторой степени
**sophisticated** *a* сложный
**sound** *n* звук
**source** *n* источник
**space** *n* пространство; промежуток времени; *a* космический; **space charge** пространственный заряд
**spacial** *a* пространственный
**specific** *a* особый, особенный; характерный
**specify** *v* точно определять
**speed** *n* скорость
**split** *v* расщеплять
**spot** *n* пятно
**square** *n* квадрат; *a* квадратный
**stable** *a* постоянный; устойчивый
**stage** *n* каскад; ступень, стадия
**state** *n* состояние
**static** *a* статический
**steady** *a* устойчивый; постоянный
**steal** *v* (*зд.*) заимствовать
**step** *n* шаг; ступень
**step up** *v* повышать
**still** *adv* до сих пор, все еще; однако
**store** *v* запасать
**straight** *a* прямой
**stress** *n* напряжение; давление; ударение
**strict** *a* строгий; точный
**strike** *v* **(struck, struck, stricken)** ударять
**striking potential** напряжение зажигания
**structure** *n* строение; структура
**subject** *v* подвергать воздействию; *n* предмет
**substantially** *adv* по существу
**substitute** *v* заменять, замещать
**substrate** *n* вещество, среда, основа
**subtract** *v* вычитать
**succeeding** *a* последующий
**successive** *a* следующий один за другим, последовательный
**suffer** *v* страдать; испытывать
**suffice (to, for)** *v* быть достаточным
**sufficient** *a* достаточный
**suggest** *v* предлагать
**suitable** *a* подходящий, годный
**superimpose** *v* накладывать; переносить; наносить
**supply** *v* питать; снабжать; *n* подача питания, источник питания
**suppose** *v* полагать; предполагать
**surely** *adv* конечно
**surplus** *n* излишек; *a* избыточный; добавочный
**surround** *v* окружать
**sustain** *v* поддерживать; выносить; выдерживать
**sweep** *n* развертка, качание, колебание
**switch** *n* выключатель; переключатель; ключ; *v* переключать; выключать; включать
**synchronizing circuit** цепь синхронизации

## T

**tank circuit** параллельный резонансный контур
**tap** *n* отвод, ответвление; зажим
**tape recording** магнитофонная запись
**technique** *n* техника, технические приемы
**tend** *v* иметь склонность; направляться; клониться
**tension** *n* растяжение; напряжение
**term** *v* называть
**terminal** *n* зажим, конец
**terminate** *v* кончаться, заканчиваться; ограничивать
**test** *v* испытывать; *n* испытание; тест
**than** *conj* чем, нежели
**then** *adv* тогда, в то время
**thermal** *a* тепловой
**thermionic** *a* термоэлектронный
**thin** *a* тонкий
**tickler coil** катушка обратной связи
**tickler feedback oscillator** гене-

ратор с независимым возбуждением
**tight** *a* плотный; непроницаемый
**time** *v* умножать; *n* время; раз
**tiny** *a* крошечный
**top** *n* верх; верхняя часть
**trace** *v* проследить, чертить; *n* след, черта
**transconductance** *n* крутизна (*характеристики лампы*)
**transducer** *n* преобразователь; датчик; приемник
**transfer** *v* передавать; перемещать, переносить; *n* передача, перенос
**transmit** *v* передавать
**transmitter** *n* передатчик
**treatment** *n* обработка
**trigger** *n* триггер; устройство для запуска
**triode** *n* триод
**trivalent** *a* трехвалентный
**tube** *n* трубка; лампа (*электронная*)
**tune** *v* настраивать; звучать
**turn** *v* поворачивать; навивать (*обмотку*); *n* виток; оборот
**turn into** преобразовывать, превращать
**turn to** обращаться к
**turns ratio** коэффициент трансформации; отношение витков

## U

**undergo** *v* (**underwent, undergone**) подвергаться; испытывать
**unidirectional** *a* однонаправленный
**unilateral** *a* односторонний
**unit** *n* единица, целое; агрегат, секция, узел, элемент
**universal** *a* всеобщий, универсальный
**utilize** *v* использовать

## V

**vacuum** *n* пустота, разряжение, вакуум
**vacuum tube** электронная лампа
**valence** *n* валентность
**value** *n* величина, значение
**vapour** *n* пар
**vapourize** *v* испаряться
**variable** *n* переменная (величина); параметр
**vary** *v* меняться, изменяться
**velocity** *n* скорость; быстрота
**vibrate** *v* колебаться; вибрировать
**vice versa** *adv* наоборот
**vicinity** *n* (*зд.*) область, зона
**view** *n* вид; осмотр
**virtually** *adv* фактически
**visible** *a* видимый; явный
**visual** *a* зрительный
**volume** *n* объем; громкость, тон

## W

**waste** *v* терять
**waveform** *n* форма сигнала, форма волны
**winding** *n* обмотка
**wire** *n* проволока; провод; проводник
**wireless** *n* радио; *a* беспроволочный
**withdraw** *v* брать назад; удалять(ся)
**within** *prep* в пределах, внутри, в
**witness** *v* наблюдать

## Y

**yet** *adv* еще; все еще; уже; *conj* однако

## KEYS TO TESTS

### Section 1

**Test 1. I:** 1. electronics. 2. a computer. 3. a huge radiotelescope. 4. a vacuum tube. 5. integrated circuits

**Test 2. I:** 1.—h, 2.—j, 3—f, 4.—b, 5.—a, 6.—i, 7.—c, 8.—g, 9.—d, 10.—e

**II:** 1.—e, 2.—a, 3.—h, 4.—f, 5.—j, 6.—i, 7.—c, 8.—b, 9—d, 10.—g

**III:** 1.—g, 2.—f, 3.—a, 4.—b, 5.—j, 6.—c, 7.—d, 8.—e, 9.—h, 10.—i

**Test 3:** 1.—b, 2.—c, 3.—c, 4.—a, 5.—d, 6.—d, 7.—d, 8.—b, 9.—c, 10.—d, 11.—c, 12.—d, 13.—a, 14.—b, 15.—c, 16.—a, 17.—c, 18.—d, 19.—d, 20.—c

**Test 4:** 1.—b, 2.—c, 3.—b, 4.—c, 5.—b, 6.—a, 7.—b, 8.—a, 9.—c, 10.—b, 11—a, 12.—c, 13.—c, 14.—c, 15.—a, 16.—b, 17.—c, 18.—b, 19.—a, 20.—c

### Section 2

**Test 1:** 1. an electron tube. 2. attractive surface forces. 3. thermionic emission. 4. field emission. 5. thermionic emission

**Test 2:** 1.—h, 2.—g, 3.—a, 4.—f, 5.—j, 6.—i, 7.—c, 8.—b, 9.—d, 10.—e

**Test 3:** 1.—c, 2.—b, 3.—d, 4.—a, 5.—b, 6.—d, 7.—c, 8.—b, 9.—d, 10.—c, 11.—c, 12.—d, 13.—b, 14.—d, 15.—b, 16.—c, 17.—d, 18.—d, 19.—c, 20.—a

**Test 4:** 1.—b, 2.—c, 3.—a, 4.—c, 5.—b, 6.—b, 7.—c, 8.—c, 9.—a, 10.—c, 11.—c, 12.—a, 13.—c, 14.—c, 15.—a, 16.—a, 17.—c, 18.—b, 19.—a, 20.—c

### Section 3

**Test 1:** 1. a diode tube. 2. like charges. 3. negative charges. 4. positive charges. 5. an electric field

**Test 2: I:** 1.—h, 2.—d, 3.—a, 4.—b, 5.—i, 6.—j, 7.—c, 8.—e, 9.—g, 10.—f

**II:** 1.—d, 2.—e, 3.—a, 4.—b, 5.—i, 6.—c, 7.—f, 8.—j, 9.—g, 10.—h

**Test 3:** 1.—c, 2.—d, 3.—a, 4.—b, 5.—c, 6.—b, 7.—c, 8.—a, 9.—d, 10.—c, 11.—b, 12.—c, 13.—a, 14.—c, 15.—a, 16.—c, 17.—c, 18.—b, 19.—d, 20.—c

**Test 4:** 1.—a, 2.—c, 3.—b, 4.—b, 5.—a, 6.—c, 7.—b, 8.—b, 9.—c, 10.—b, 11.—a, 12.—a, 13.—c, 14.—c, 15.—b, 16.—a, 17.—c, 18.—b, 19.—a, 20.—c

## Section 4

* 1.—AC, 2.—BD, 3.—AB, 4.—AC, 5.—ABD, 6.—AC, 7.—AD[1]
* 1.—B, 2.—A, 3.—ACD, 4.—B, 5.—C, 6.—A, 7.—AD, 8.—C

**Test 1:** 1. a triode tube. 2. a control grid. 3. a grid. 4. a plate. 5. a grid. 6. a signal voltage

**Test 2:** **I:** 1.—b, 2.—j, 3.—i, 4.—c, 5.—h, 6.—g, 7.—e, 8.—f, 9.—a, 10.—d
**II:** 1.—d, 2.—c, 3.—e, 4.—i, 5.—j, 6.—h, 7.—f, 8.—g, 9.—b, 10.—a
**III:** 1.—f, 2.—e, 3.—a, 4.—c, 5.—i, 6.—g, 7.—j, 8.—d, 9.—h, 10.—b
**IV:** 1.—i, 2.—e, 3.—j, 4.—a, 5.—b, 6.—c, 7.—d, 8.—f, 9.—h. 10.—g

**Test 3:** 1.—d, 2.—c, 3.—b, 4.—a, 5.—c, 6.—b, 7.—d, 8.—d, 9.—c, 10.—b, 11.—c, 12.—a, 13.—b, 14.—d, 15.—c, 16.—d, 17.—a, 18.—b, 19.—a, 20.—b

**Test 4:** 1.—c, 2.—c, 3.—a, 4.—b, 5.—a, 6.—b, 7.—a, 8.—b, 9.—a, 10.—c, 11.—b, 12.—c, 13.—a, 14.—a, 15.—b, 16.—c, 17.—c, 18.—b, 19.—a, 20.—b

## Section 5

* 1.—D, 2.—A, 3.—D, 4.—A

**Test 1:** 1. a cathode-ray tube. 2. an oscillograph. 3. electrons. 4. an electrostatic field. 5. an electron gun. 6. the vertical deflecting plates

**Test 2.** **I:** 1.—i, 2.—f, 3.—h, 4.—b, 5.—j, 6.—d, 7.—a, 8.—g, 9.—e, 10.—c
**II:** 1.—d, 2.—a, 3.—f, 4.—j, 5.—c, 6.—g, 7.—b, 8.—e, 9.—h, 10.—i
**III:** 1.—d, 2.—j, 3.—a, 4.—b, 5.—c, 6.—i, 7.—f, 8.—e, 9.—g, 10.—h
**IV:** 1.—b, 2.—j, 3.—h, 4.—f, 5.—c, 6.—i, 7.—d, 8.—a, 9.—g, 10.—e

**Test 3:** 1.—d, 2.—d, 3.—c, 4.—d, 5.—b, 6.—b, 7.—b, 8.—b, 9.—b, 10.—c, 11.—d, 12.—a, 13.—c, 14.—d, 15.—c, 16.—b, 17.—c, 18.—d, 19.—a, 20.—b

**Test 4:** 1.—c, 2.—c, 3.—a, 4.—b, 5.—b, 6.—c, 7.—a, 8.—b, 9.—a, 10.—b, 11.—a, 12.—b, 13.—a, 14.—b, 15.—c, 16.—a, 17.—c, 18.—a, 19.—в, 20.—c

## Section 6

* 1.—BC, 2.—ACD, 3.—BD, 4.—C, 5.—AC

**Test 1:** 1. a transistor. 2. a transistor. 3. germanium. 4. *n*-type germanium. 5. *p*-type germanium. 6. a transistor

**Test 2.** **I:** 1.—d, 2.—a, 3.—f, 4.—b, 5.—g, 6.—c, 7.—e, 8.—j, 9.—h, 10.—i
**II:** 1.—e, 2.—f, 3.—i, 4.—a, 5.—b, 6.—c, 7.—j, 8.—d, 9.—g, 10.—h
**III:** 1.—b, 2.—h, 3.—a, 4.—j, 5.—c, 6.—i, 7.—d, 8.—e, 9.—f, 10.—g
**IV:** 1.—g, 2.—h, 3.—i, 4.—b, 5.—c, 6.—j, 7.—f, 8.—a, 9.—d, 10.—e

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[1] См. Предисловие, стр. 6.

**V:** 1.—c, 2.—j, 3.—e, 4.—b, 5.—d, 6.—a, 7.—f, 8.—i, 9.—g, 10.—h

**VI:** 1.—f, 2.—g, 3.—b, 4.—j, 5.—a, 6.—d, 7.—c, 8.—i, 9.—h, 10.—e

**VII:** 1.—d, 2.—a, 3.—i, 4.—b, 5.—j, 6.—c, 7.—h, 8.—e 9.—f, 10.—g

**Test 3:** 1.—d, 2.—b, 3.—c, 4.—d, 5.—c, 6.—d, 7.—a, 8.—d, 9.—b, 10.—a, 11.—b, 12.—c, 13—a, 14.—d, 15.—b, 16.—a, 17.—c, 18.—c, 19.—d, 20.—c

**Test 4:** 1.—c, 2.—b, 3.—c, 4.—a, 5.—c, 6.—a, 7.—c, 8.—c, 9.—c, 10.—b, 11.—b, 12.—c, 13.—a, 14.—b, 15.—c, 16.—a, 17.—b, 18.—a, 19.—a, 20.—c, 21.—c, 22.—b, 23.—b, 24.—c, 25.—b

## Section 7

**Test 1.** 1. an amplifier. 2. out of phase. 3. signal voltage. 4. high amplification. 5. a transistor amplifier

**Test 2. I:** 1.—j, 2.—a, 3.—g, 4.—b, 5.—d, 6.—c, 7.—e, 8.—i, 9.—f, 10.—h

**II:** 1.—c, 2.—j, 3.—a, 4.—b, 5.—d, 6.—i, 7.—e, 8.—g, 9.—h, 10.—f

**III:** 1.—d, 2.—a, 3.—b, 4.—j, 5.—c, 6.—i, 7.—e, 8.—h, 9.—f, 10.—g

**IV:** 1.—c, 2.—a, 3.—j, 4.—b, 5.—d, 6.—i, 7.—e, 8.—g, 9.—f, 10.—h

**V:** 1.—e, 2.—j, 3.—a, 4.—b, 5.—i, 6.—c, 7.—d, 8.—h, 9.—f, 10.—g

**VI:** 1.—f, 2.—j, 3.—h, 4.—b, 5.—a, 6.—c, 7.—i, 8.—d, 9.—e, 10.—g

**Test 3:** 1.—c, 2.—a, 3.—b, 4.—a, 5.—c, 6.—b, 7.—a, 8.—d, 9.—c, 10.—c, 11.—d, 12.—b, 13.—b, 14.—c, 15.—a, 16.—d, 17.—a, 18.—d, 19.—a, 20.—b

**Test 4:** 1.—a, 2.—c, 3.—a, 4.—a, 5.—b, 6.—b, 7.—c, 8.—b, 9.—c, 10.—a, 11.—a, 12.—b, 13.—a, 14.—b, 15.—c, 16.—a, 17.—b, 18.—a, 19.—b, 20.—a

## Section 8

**Test 1:** 1.—a, 2.—b, 3.—c, 4.—a, 5.—a, 6.—a, 7.—b, 8.—c, 9.—a, 10.—c, 11.—a, 12 —c, 13.—a, 14.—b, 15.—c, 16.—a, 17 —c, 18.—b, 19.—a, 20.—a

## Section 9

**Test 1:** 1.—b, 2.—c, 3.—b, 4.—a, 5.—c, 6.—b, 7.—a, 8.—a, 9.—a, 10.—a, 11.—c, 12.—a, 13.—b, 14.—c, 15.—a, 16.—b, 17.—b

## Section 10

**Test 1:** 1.—c, 2.—b, 3.—a, 4.—b, 5.—b, 6.—a, 7.—b, 8.—c, 9.—c, 10.—a, 11,—a, 12.—c, 13.—b, 14.—a, 15.—c

## THE RUSSIAN TRANSLATION OF THE TEXT "TRIODE CONSTANTS"

### ПАРАМЕТРЫ ТРИОДА

1. Семейство характеристик триода, которые отпределяют характерные свойства каждого типа ламп, не являются случайными. Скорее они представляют результат целенаправленной разработки, задачей которой являлось создание лампы, имеющей определенные свойства. Конструктивные данные лампы выражаются рядом величин, называемых параметрами лампы. Три наиболее важных параметра следующие: коэффициент усиления, внутреннее сопротивление и крутизна характеристики.

2. Коэффициент усиления триода является оценкой относительной эффективности управляющей сетки в преодолении электростатического поля, создаваемого анодом. Для того чтобы определить величину коэффициента усиления, достаточно изменить на определенную величину анодное напряжение, записать изменение анодного тока, а затем изменить напряжение на сетке так, чтобы восстановить первоначальное значение анодного тока. Сравнивая изменение анодного и сеточного напряжений при одном и том же изменении анодного тока, мы можем определить их относительную эффективность, которая является коэффициентом усиления.

3. Мы можем определить его следующим образом: коэффициент усиления $\mu = -\frac{\Delta E_a}{\Delta E_g}$ (при постоянной величине $I_a$), где $\Delta E_a$ — малое приращение анодного напряжения; $\Delta E_g$ — малое приращение сеточного напряжения.

4. Внутреннее сопротивление характеризует сопротивление лампы переменному анодному току, когда к электродам приложено изменяющееся напряжение. Внутреннее сопротивление переменному току определяется как отношение малого приращения анодного напряжения к вызываемому им малому приращению анодного тока, в то время как сеточное напряжение поддерживается постоянным.

5. Выражая это определение в виде формулы, получаем: сопротивление лампы переменному току $R_l = \frac{\Delta E_a}{\Delta I_a}$, где $\Delta I_a$ представляет малое приращение анодного тока.

6. Третьим параметром, применяемым для описания свойств ламп, является крутизна, обозначаемая символом $S$. Крутизна является наиболее важным параметром

лампы, так как она определяет насколько эффективно сетка управляет изменениями анодного тока лампы.

7. Она определяется как отношение малого приращения анодного тока к вызывающему его малому приращению сеточного напряжения. Выражая это в виде формулы, получаем:

крутизна: $S = \frac{\Delta I_a}{\Delta E_g}$ (при постоянной величине $E_a$).

8. Все эти три величины $\mu$, $R_i$, $S$ могут быть определены из анодных или анодно-сеточных характеристик лампы. Если известны две из них, третья находится легко, так как всегда имеет место равенство: $\mu = R_i S$

Рассмотренные нами параметры ламп широко используются при конструировании и анализе схем на электронных лампах.

## THE RUSSIAN TRANSLATION OF THE TEXT "FEEDBACK AMPLIFIERS"

## УСИЛИТЕЛИ С ОБРАТНОЙ СВЯЗЬЮ

1. Обратной связью называют передачу части энергии с выхода усилителя обратно на его вход. Она оказывается весьма полезной, так как уменьшает искажения, возникающие в усилителях, и делает работу усилителя более стабильной по отношению к изменениям коэффициента усиления, вызываемым колебаниями сетевого напряжения, сменной лампы, их старением и т. д.

2. Обратная связь бывает двух типов: регенеративная или положительная обратная связь и отрицательная обратная связь. Когда сигнал обратной связи поступает в фазе с входным сигналом, имеет место регенеративная или положительная обратная связь. Об отрицательной обратной связи говорят тогда, когда сигнал обратной связи находится в противофазе с входным сигналом.

3. Положительная обратная связь увеличивает коэффициент усиления усилителя. Напротив, отрицательная обратная связь уменьшает коэффициент усиления, но одновременно она уменьшает и искажения, вносимые усилителем, благодаря этому мы будем рассматривать в основном отрицательную обратную связь. Коэффициент усиления усилителя, охваченного отрицательной обратной связью, $K = -\frac{A}{1 + \beta A}$, где $A$ является коэффициентом уси-

лителя без обратной связи, а $\beta$ — коэффициентом обратной связи.

4. Когда произведение $\beta A$ становится много больше единицы, предыдущее выражение преобразуется к виду $K = \frac{1}{\beta A}$. Коэффициент усиления усилителя при этом невелик, но зато он зависит только от коэффициента обратной связи $\beta$ и, таким образом, совершенно независим от коэффициента усиления $A$ усилителя.

5. В результате этого, коэффициент усиления усилителя с сильной отрицательной обратной связью весьма стабилен и практически не зависит от изменения напряжения питания и старения ламп. Более того, поскольку усиление зависит только от коэффициента обратной связи $\beta$, изменение коэффициента усиления с частотой или частотная характеристика полностью определяется характером коэффициента $\beta$.

6. Если сигнал обратной связи подается через резистивную цепь, обратная связь и, следовательно, коэффициент усиления не меняется при изменении частоты. Таким образом, частотная характеристика усилителя может быть существенно улучшена путем применения сильной отрицательной обратной связи.

7. Фон, шумы и искажения, вносимые усилителем, при введении отрицательной обратной связи уменьшаются так же, как и усиление, в $1 + \beta A$ раз. Поскольку потери в усилении всегда могут быть скомпенсированы увеличением амплитуды входного сигнала, применение отрицательной обратной связи позволяет уменьшить величину искажений, шумов и фона.